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**Status of the Silver Hake Resource off
the Northeast Coast of the United States - 1987**

by

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EXECUTIVE SUMMARY

Gulf of Maine - Northern Georges Bank Stock

Total nominal catches from this stock were 8,502 mt in 1986, a slight 2% increase over 1985 and continuing a trend of increases since 1979. The 1986 catch was taken exclusively by the US. Spring and autumn survey catch-per-tow indices indicate a generally increasing trend from low levels recorded in the early 1980's with 1986 levels among the highest in the series'. Total stock biomass at the beginning of 1987 from VPA was estimated to be 64,000 mt, an 8% increase over 1986, and a threefold increase over the record low level in 1980. Spawning stock biomass was estimated to be about 34,000 mt, a 55% increase over 1986, and also a threefold increase over a record low in 1981. Recruitment in 1986 was estimated to be about 230 million fish, the highest level since the 1973 cohort. Assuming recruitment of 120 million fish in 1987, a catch of 10,700 mt could be taken in 1987 while maintaining a constant stock size from 1987 to 1988. Fishing at $F_{0.1}$ in 1987 would produce a catch of about 14,300 mt and would reduce age 2+ stock size in 1988 by about 8%.

Southern Georges Bank - Middle Atlantic Stock

Total international catch in 1986 was 10,123 mt, a 23% decrease from 1985 and continuing low levels of reported catches since about 1980, when compared to the mid-1960's and mid 1970's. The US commercial catch was 9,408 mt, it's lowest level since 1975, and a 21% drop from the 1980-1985 average. Recreational catch in 1986 was estimated to be approximately 94 mt. The distant water fleet reported catches of 550 mt in 1986, made up of landings from Italy, Japan, Spain and the GDR. NEFC bottom trawl survey indices have indicated an increase in abundance in this stock since the early 1980's. Total stock biomass at the beginning of 1987 was estimated to be 58,000 mt, a 6% increase over 1986 and a 26% increase over the record low in 1981. Spawning stock biomass was estimated to be about 35,000 mt in 1987. This level represents a 11% increase over 1986, and an 46% increase over the record low in 1983. Recruitment was estimated to be about 200 million fish in both 1986 and 1987, respectively. Assuming this level of recruitment, a catch of about 12,600 mt could be taken in 1987 with no change in age 2+ stock size from 1987 to 1988. Fishing at $F_{0.1}$ in 1987 would produce a catch of about 11,500 mt and would allow a 2% increase in stock size from 1987 to 1988.

INTRODUCTION

This document presents an analysis of the status of the silver hake *Merluccius bilinearis* (Mitchell) stocks inhabiting the waters off the northeast coast of the United States from Cape Hatteras, NC to the Fundian Channel. The assessment represents a departure from those performed in the past in that the silver hake resource is now assessed based upon a two stock division of the population, while past assessments (i.e. Almeida and Anderson 1981) were presented utilizing a three stock scheme. Recently completed stock delineation studies which examined research vessel survey and commercial fishery catch data, and utilized a multivariate statistical analysis of morphometric data, indicate that silver hake should be assessed as two stocks (Almeida 1987). These are a northern stock including fish from the Gulf of Maine and northern Georges Bank, and a southern stock comprised of silver hake inhabiting the waters from southern Georges Bank to Cape Hatteras (Figure 1).

The data used in this report include US and foreign commercial catch statistics, estimated US recreational catches (southern stock only) for 1955-1986, and US research vessel bottom trawl survey results from 1963-1986. Estimates of past levels of stock size and fishing mortality (F) calculated from virtual population analysis (VPA) are presented. Recruitment estimates for the 1985 and 1986 year classes, predicted from relationships between research vessel mean catch per tow at age and estimates of year-class size at age 1 from VPA, are also given. Catch levels in 1987 at varying levels of F and resulting 1988 stock sizes were projected under assumptions of estimated recruitment in 1987.

Allocation of Catches to Stock

Prior to performing the assessment, catches taken from Georges Bank were allocated between the northern and southern stocks. Annual US commercial catches taken on Georges Bank were allocated based upon the Statistical Area (SA) from which they were reported. Those catches reported from the northern portion of the Bank (SA 521-523) were allocated to the Gulf of Maine - Northern Georges Bank stock (SA 511-523), and those from the southern portion (SA 524-526) were allocated to the Southern Georges Bank - Middle Atlantic stock (SA 524-600+). Annual distant-water-fleet (DWF) catches from Georges Bank for 1962-1976 were divided between the northern and southern portions of the Bank utilizing US Coast Guard overflight data. During the period, the Coast Guard prepared detailed information on the distribution and catches of all DWF vessels fishing off the coast of the US on a monthly basis. From this information, the proportion of each country's vessels taking silver hake in each Statistical Area was calculated. Assignment of catches to statistical area was then made based on each country's monthly percentage of vessel activity in each of the areas. The results indicated that approximately 29% of the annual DWF catch from Georges Bank during 1962-1976 was taken from SA 521-523, with the remaining 71% caught in SA 524-526. Since implementation of the Magnuson Fishery Conservation and Management Act (MFCMA) in 1977, the DWF has been restricted to fishing windows along the outer continental shelf and therefore the entire catch has been taken from the Southern Georges Bank - Middle Atlantic stock.

GULF OF MAINE - NORTHERN GEORGES BANK STOCK

Catch History

Total nominal catches of silver hake from the Gulf of Maine - Northern Georges Bank stock have demonstrated four general trends since 1955. The fishery was characterized by relatively stable catches during 1955-1961, a period of high catches during 1962-1964 with the introduction of the DWF, followed by a period of slow but steady decline from 1965-1978. The most recent period, since 1979, has seen a steady increase, however at very low levels when compared to earlier years (Table 1 and Figure 2). Total catches from the area averaged approximately 49,100 mt during 1955-1961, but increased sharply due to DWF catch to a series high of 94,500 mt in 1964. Catches dropped sharply in 1965, and then continued a slow decline to only 3,400 mt in 1979. Catches have increased steadily since 1979; the total catch in 1986 was 8,502 mt, taken exclusively by the US.

US commercial catches, after reaching a high of 62,800 mt in 1957, demonstrated a generally decreasing trend through 1972, when the total catch was only 6,400 mt (Table 1 and Figure 2). Catches then increased to an average of 12,000 mt during 1973-1978, but declined sharply in 1979 to 3,400 mt. Catches by the US have increased steadily since 1979.

The distant water fleet reported catches from the Gulf of Maine - northern Georges Bank area from 1962 to 1977. Countries that participated in this fishery included Bulgaria, Canada, Cuba, the Federal Republic of Germany (FRG), the German Democratic Republic (GDR), Japan, Poland, Romania, and the USSR, however, the USSR catch clearly dominated. The DWF catch of 36,600 mt in 1962 (46% of the total) taken by the USSR, increased rapidly to 57,200 mt

in 1964 (61% of the total), but declined steadily to only 6,900 mt in 1967. Catches then varied widely from the low in 1967 to a high of 27,300 mt in 1975. In 1976, catches dropped to 151 mt and in March of 1977, the DWF was excluded from this fishery after reporting a catch of only 2 mt in that year.

Commercial Catch Composition

The estimated commercial catches at age (in numbers) for 1955-1984 are presented in Table 2. During 1955-1971, the predominant ages of fish in the catch were ages 3-4, averaging about 61% of the total in numbers in each year. During 1972-1973, there was a sharp shift toward very young, age 1-2 fish comprising 81% of the total, the result of the DWF concentrating on the strong 1971 and 1972 year classes. In 1974, ages 1-3 dominated the catch (85% of the total), and during 1975-1978, ages 2-4 averaged about 81% of the total catch in each year. In the most recent years, 1979-1986, ages 2-3 have comprised an average of 64% of the catch annually.

Calculated mean weights (kg) at age for 1955-1986 catches are given in Table 3. These values were generated by the application of quarterly length-weight equations to commercial catch length frequency data. The mean weights were applied to the numbers-at-age data in Table 2 to obtain calculated catches (mt) in each year.

Abundance Indices

Commercial Catch per Effort

The US commercial catch-per-effort index (US days fished) was calculated using otter trawlers of tonnage classes 2 and 3 (5-150 gross registered tons) from trips in which silver hake were assumed to be the main species sought

sought (i.e. the silver hake catch made up at least 50% of the total trip catch). These vessels represent both day boats and short trip-type boats that dominate the fishery in the Gulf of Maine - northern Georges Bank area. Over 95% of the total catch of silver hake is taken by otter trawl. The US catch-per-day index ranged between 5.3 and 19.5 mt/day during 1964-1986 (Table 1 and Figure 3). The index declined from a series high of 19.5 mt/day in 1964 to a low of only 5.3 mt/day in 1972, but increased rapidly to 13.2 mt/day in 1976. The index declined steadily to 6.0 mt/day in 1983, rose sharply to 9.7 mt/day in 1984, and declined thereafter to 5.6 in 1986. Trends in this index have been reasonably consistent over time with changes in stock biomass calculated from VPA.

Research Vessel Mean Catch per Tow

Spring and autumn bottom trawl survey indices were calculated utilizing Delta distribution estimators (Pennington 1983, Almeida et al. 1986) for offshore strata only and adjusted to the #36 Yankee trawl as the standard gear. An intervention analysis was used to model the spring survey time series to determine the effect of the change in trawl gear from the #36 trawl (used during 1968-1972 and 1982 to present) to the higher opening #41 trawl (used during 1973-1981) (see Fogarty et al. (1986) for discussion of the analytical procedure). As a result of the analysis, survey catches during the spring 1973-1981 were adjusted using ratios of 0.400:1 and 0.334:1 for weight and numbers, respectively. The spring and autumn time series were then fitted to an ARIMA model to smooth random variability in the estimators (Pennington 1983, Fogarty et al. 1986). The basic assumption to this approach was that the size of a multi-age class stock would not be expected to change radically

from year to year unless some causative force could be identified (Conservation and Utilization Division, 1986). The values of *theta*, the model smoothing parameter, were 0.4 and 0.5 for the mean weight and number per tow series', respectively. The fitted indices were utilized to examine trends in stock abundance throughout the assessment analysis.

The fitted spring survey weight-per-tow index (Table 4 and Figure 4), after recording very low levels in 1968-1969 (averaging 0.2 kg), rose steadily to a series high of 3.6 kg in 1975 but declined rapidly to 1.2 kg by 1978. The index remained fairly steady, averaging about 1.5 kg during 1979-1984 but increased to 2.7 kg in 1986.

Catch per tow in numbers, demonstrated a generally increasing trend from a low of 2.5 in 1968 to a high of 43.7 in 1975, followed by a steady decrease to 15.2 in 1978 (Table 4 and Figure 5). The index then increased and remained steady during 1979-1983, averaging 20.4, and subsequently increased to 50.1 in 1986, the highest level in the time series.

The fitted autumn weight-per-tow index declined sharply from 12.9 kg in 1963 to 7.0 kg in 1964, then declined gradually to a series low of 2.5 kg in 1968. The index then increased steadily to 8.8 in 1976, but was followed by a period of steady decline to 5.3 kg in 1981. During 1980-1984, the index remained fairly steady, averaging 6.0 kg. In 1986, the index increased sharply to 10.6, its highest level since 1963.

Catch per tow in numbers from the autumn survey decreased from a high of 73.3 in 1963 to a series low of 13.3 in 1968 then followed a generally increasing trend to 47.2 in 1975 and 1976. The index showed a general decrease through 1981, but has increased steadily to 84.5 in 1986, the highest level in the time series.

The precision of the catch-per-tow indices (unfitted), both in weight and number, was evaluated by calculating coefficients of variation (CV), defined as the ratio of the standard deviation to the mean in each survey, on a linear scale (Appendix Tables 1 and 2). Coefficients of variation for the mean weight-per-tow indices averaged 0.28 and 0.22 for the spring and autumn surveys, respectively. Average CV's in mean numbers-per-tow were 0.25 and 0.21 for the spring and autumn surveys, respectively. These results indicate that the precision of the estimators for silver hake are, in general, quite good when compared to other demersal species sampled by the NEFC bottom trawl survey (Almeida et al. 1986).

Mean Catch per Tow at Age

Mean catch per tow at age for 1973 (the first year age samples were collected during the survey) to 1986 was determined by first applying annual age-length keys to the appropriate length frequency data from spring and autumn bottom trawl surveys (Appendix Table 3), then calculating proportions at age for each survey. The proportions were then applied to the fitted number-per-tow indices for each survey to obtain fitted annual catch-per-tow-at-age indices (Table 5). Ages ranged from 1 to 14 in the spring surveys and 0 to 13 in the autumn, but individuals older than about age 9 were rarely encountered (ages 9 and older are combined in the Table). The data indicate that there have been, in alternating two year cycles, strong and weak year classes beginning in 1973. The 1973 and 1974 year classes were quite strong and were well represented in the commercial catch-at-age data. The 1975-1976 year classes were relatively weak in comparison to previous years, while the 1977-1978 cohorts appeared to be quite strong (although not as strong as the

1973-1974). The cycle continued during 1979-1982 with alternating weak (1979-1980) and strong (1981-1982) year classes. The cycle may have been broken in 1984 however. After a relatively weak 1983 cohort, the 1984-1985 year classes appear to be strong, while the 1986 year class may be of only average strength.

Fishing Mortality

Fishing mortality (F) for fully recruited ages in 1986, the terminal year in the VPA, was estimated from a power curve regression between fishing mortality from VPA and an index of relative exploitation derived from the NEFC autumn survey time series. The relative exploitation index was calculated by dividing the total international catch for 1973-1984 by the fitted autumn survey catch per tow in numbers index for ages 2 and older. Annual fishing mortality estimates were determined for 1955-1985 as the weighted (by stock size) mean F for fully recruited ages obtained from VPA. This estimate was used as the F value for the oldest true age class and plus group in each year. Terminal F in 1986 was selected using an iterative process consisting of alternate computations of VPA and the F-exploitation regression until the F value predicted from the regression and the terminal F value in the VPA reached convergence. The F value for 1986 was 0.46 ($r=0.727$, $p<0.01$) for ages 2 and older (Table 6).

Fishing mortalities for fully recruited ages determined from VPA (Table 7) ranged between 0.19 and 1.29 during 1955-1986 and averaged 0.43. Before the introduction of the DWF, F was fairly steady, averaging 0.27 during 1955-1961, however, F rose rapidly with the increased effort placed on the stock beginning in 1962 and reached 0.70 in 1964. In 1965, both landings and

F dropped sharply and F stabilized at an average of 0.41 during 1965-1970. F increased dramatically in 1971, reaching 1.29, but dropped to 0.42 in 1972 and fluctuated in alternate years during 1972-1978 between 0.28 and 0.78 before dropping to 0.19 in 1979 after the inception of MFCMA. Since 1979, F has remained fairly steady averaging 0.41 through 1986.

Recruitment

The sizes of the 1954-1984 year classes at age 1, estimated from VPA, ranged between 44 million fish (1976 year class) and 1.3 billion fish (1959 year class) with a mean size of 475 million and a median of 323 million (Table 8 and Figure 6). Every year class since 1964 has fallen below the mean, while all those since 1974 were below the median level. An estimate of the 1985 year class was obtained through a power curve regression between fitted spring survey catch per tow at age 1 (numbers) and year-class size at age 1 (millions) from VPA ($r=0.806$, $p<0.01$) (Table 10). The estimate of year-class size from the regression (230.7 million) was rounded to 230 million fish before use in stock size estimates and projections.

Recruitment in this stock during 1955-1964 was at very high levels (average = 1.0 billion) before heavy fishing pressure during the mid-1960's decreased spawning stock biomass and subsequent year-class strength. Recruitment during the 1960's plunged from a series high of 1.3 billion fish (the 1959 year class) to 185 million (1969 year class). Strong year classes in 1971-1973 produced average sizes of 387 million but recruitment then dropped rapidly to a low of only 44 million for the 1976 cohort. Since 1976, year-class strength has been variable at levels much lower than those observed in the 1950's and 1960's, with the exception of the strong 1985 year class.

Stock Biomass

Age-specific stock size estimates (in millions) for 1955-1987 were obtained from VPA (Table 8). Mean weights at age (Table 3) were applied to stock numbers at age to obtain stock biomass values (Table 9).

Total stock biomass (ages 1+) increased from 316,100 mt in 1957 to a high of 429,000 mt in 1961, then began a steady ten year decline to 78,500 mt in 1971 (Table 9 and Figure 2). Biomass increased to 137,500 mt in 1974 due to above average recruitment in 1972-1974. However, from 1975 through 1981, the stock declined to its lowest level of only 21,200 mt in 1980. Since then, stock size has improved steadily and was estimated to be 64,400 mt at the beginning of 1987.

Spawning stock biomass was estimated by applying a maturity ogive (Morse 1979) to stock biomass at age values from VPA. Percent mature at age values were 0% at age 1, 59% at age 2, 95% at age 3, and 100% at ages 4 and older. Spawning stock biomass increased from 251,800 mt in 1958 to a high of 301,900 mt in 1962 then began a steady ten year decline to 47,900 mt in 1972 (Table 9 and Figure 6). As a result of strong 1971-1973 cohorts, spawning biomass increased to 73,700 mt in 1975, but declined to only 12,000 mt by 1982. Spawning biomass has increased since 1981 to an estimated 33,500 mt at the beginning of 1987.

Partial Recruitment

Age specific fishing mortality rates from VPA indicate that silver hake were generally fully recruited to the commercial fishery by age 3 during 1955-1971, but full recruitment was reached by age 2 during 1971-1986. This was likely the result of a decrease in the abundance of older individuals

(ages 3+) in the stock due to overfishing. Partial recruitment of an age group to the fishery, defined as the ratio between F at a given age (in a given year) and the mean F for fully recruited ages in that year, was estimated to be 4% at age 1 and 100% at ages 2 and older in 1986. These estimates were used in the projections of catch and stock size for 1987-1988.

Yield Per Recruit

Yield-per-recruit analysis using the Thompson and Bell (1934) model was performed to estimate $F_{0.1}$ and F_{max} . The analysis was performed to obtain a reference point applicable to the conditions in the fishery during the most recent period of exploitation. Therefore, average partial recruitment values (exploitation pattern) and weights at age for the period 1979-1984 were used. Results indicated that $F_{0.1}$ for this stock is 0.44, and F_{max} is greater than 2.00.

Catch and Stock Size Projections

Projections of catch in 1987 and stock size in 1988 were calculated under two options of recruitment in 1987, 90 million fish, the average level during the 10 years, 1976-1985, and 120 million, a value equal to the 5 year (1981-1985) mean. Fishing mortality values ranging from 0.05 to 0.60 were also considered. The results of the catch and stock size projections are given in Table 11.

If recruitment into the fishery in 1987 is about 90 million fish, fishing at $F_{0.1}$ would result in a catch of about 14,400 mt, and would leave an age 2+ biomass of 39,200 mt in 1988, approximately a 17% decrease from 1987 (Table 11). A catch of 6,500 mt in 1987, requiring an F of 0.18, would leave age 2+

biomass unchanged from 1987 to 1988.

If recruitment in 1987 is 120 million, fishing at $F_{0.1}$ would result in a catch of about 14,300 mt, but the resulting biomass in 1988 would be 43,500 mt, an 8% decrease from 1987. A catch of 10,700 mt in 1987, requiring an F of 0.31, would leave age 2+ biomass unchanged from 1987 to 1988.

Table 1. Silver hake catches (mt) from the Gulf of Maine - Northern Georges Bank stock.

Year	Bulgaria	Canada	Cuba	FRG	GDR	Japan	Poland	Romania	USSR	Other ¹	USA Comm.	Total	USA catch/day
1955	-	-	-	-	-	-	-	-	-	-	53,361	53,361	-
1956	-	-	-	-	-	-	-	-	-	-	42,150	42,150	-
1957	-	-	-	-	-	-	-	-	-	-	62,750	62,750	-
1958	-	-	-	-	-	-	-	-	-	-	49,903	49,903	-
1959	-	-	-	-	-	-	-	-	-	-	50,608	50,608	-
1960	-	-	-	-	-	-	-	-	-	-	45,543	45,543	-
1961	-	-	-	-	-	-	-	-	-	-	39,688	39,688	-
1962	-	-	-	-	-	-	-	-	36,575	-	42,427	79,002	-
1963	-	-	-	-	-	-	-	-	37,525	-	36,399	73,924	-
1964	-	-	-	-	-	-	-	-	57,240	-	37,222	94,462	19.51
1965	-	-	-	-	-	-	-	-	15,793	-	29,449	45,242	17.48
1966	-	-	-	-	-	-	-	-	14,239	-	33,477	47,716	16.06
1967	-	-	-	-	3	-	-	-	6,879	-	26,489	33,371	18.52
1968	-	-	-	-	-	-	60	-	10,434	12	30,873	41,379	14.55
1969	-	-	-	-	38	19	57	1	7,813	119	15,917	23,964	8.00
1970	-	-	-	-	-	5	11	10	12,279	-	15,223	27,528	7.01
1971	1,293	-	119	-	-	45	112	-	23,674	-	11,158	36,401	8.06
1972	1,737	-	-	357	178	1	-	42	16,469	-	6,440	25,224	5.26
1973	48	-	-	29	144	18	-	-	17,847	-	13,997	32,083	10.41
1974	61	1	-	48	27	-	27	135	13,476	-	6,905	20,680	7.06
1975	-	2	1,304	37	29	-	358	122	25,456	-	12,566	39,874	8.40
1976	-	-	-	81	-	1	4	-	65	-	13,483	13,634	13.16
1977	-	-	-	-	-	-	-	-	2	-	12,455	12,457	13.32
1978	-	-	-	-	-	-	-	-	-	-	12,609	12,609	9.48
1979	-	-	-	-	-	-	-	-	-	-	3,415	3,415	7.10
1980	-	-	-	-	-	-	-	-	-	-	4,730	4,730	6.47
1981	-	-	-	-	-	-	-	-	-	-	4,416	4,416	6.19
1982	-	-	-	-	-	-	-	-	-	-	4,656	4,656	6.23
1983	-	-	-	-	-	-	-	-	-	-	5,310	5,310	6.04
1984	-	-	-	-	-	-	-	-	-	-	8,289	8,289	9.69
1985	-	-	-	-	-	-	-	-	-	-	8,297	8,297	7.98
1986	-	-	-	-	-	-	-	-	-	-	8,502	8,502	5.85

¹Non-member ICNAF countries.

Table 2. Commercial catch at age (millions of fish) of silver hake from the Gulf of Maine - Northern Georges Bank stock (+ denotes less than .1 million).

Year	Age									Total
	1	2	3	4	5	6	7	8	9+	
1955	17.0	19.9	50.2	69.2	30.4	13.7	6.5	3.3	1.5	211.8
1956	16.2	12.7	36.5	61.2	26.4	10.1	4.2	1.9	.9	170.2
1957	52.8	19.5	58.8	84.8	41.6	17.9	6.7	3.1	1.3	286.6
1958	20.9	20.2	40.1	57.6	28.4	17.2	5.7	2.8	1.2	194.2
1959	10.1	30.0	58.2	54.2	26.8	12.8	6.2	3.2	1.1	202.7
1960	4.4	37.7	76.2	53.2	20.8	8.8	4.7	2.3	.9	209.0
1961	1.1	23.2	59.7	51.5	18.9	8.0	4.1	1.9	.8	169.1
1962	2.6	33.5	127.2	122.8	47.4	12.5	5.9	2.2	1.0	355.1
1963	14.9	48.3	136.9	103.0	29.2	10.3	4.6	2.5	1.3	351.0
1964	1.4	46.6	133.1	123.4	50.2	20.6	11.7	5.6	2.1	394.9
1965	4.0	23.9	84.2	54.0	18.3	7.4	4.0	2.2	1.2	199.2
1966	5.3	20.3	82.6	70.9	19.8	6.5	3.3	1.9	1.1	211.7
1967	.7	5.3	32.5	54.9	20.3	5.3	2.4	1.1	.5	123.0
1968	1.3	4.0	25.8	49.5	36.5	13.7	5.0	1.9	.9	138.6
1969	3.1	10.6	16.8	21.3	16.2	9.1	5.0	1.9	1.0	85.0
1970	24.8	16.0	32.4	34.1	13.4	7.0	4.4	2.2	.8	135.2
1971	4.0	24.3	73.8	49.8	19.8	7.1	2.9	1.9	.8	184.4
1972	78.2	44.5	18.2	4.2	2.2	.7	.2	.1	.3	148.5
1973	33.4	91.5	24.2	4.5	1.8	.4	.1	.1	.2	156.1
1974	21.6	31.7	22.4	9.2	2.7	1.0	.4	.2	.2	89.4
1975	8.7	60.1	63.4	20.3	7.9	2.3	.5	.2	.4	164.0
1976	1.7	19.2	24.6	8.7	2.9	1.3	.2	-	-	58.7
1977	1.8	8.7	22.6	14.9	3.0	.5	.2	+	-	51.6
1978	2.7	8.3	7.1	10.8	13.5	2.4	.5	.3	+	45.5
1979	.7	3.5	2.3	1.4	1.8	2.3	.4	+	-	12.4
1980	1.1	11.8	12.1	2.0	.5	.5	.8	.2	+	29.0
1981	4.9	8.4	7.4	4.0	.6	.2	.2	.2	+	25.9
1982	5.9	9.8	2.9	3.0	2.2	.1	.2	.1	.1	24.3
1983	2.6	14.1	4.0	1.8	1.7	.7	.2	.1	+	25.2
1984	3.0	21.5	9.8	3.0	1.0	.7	+	+	+	39.1
1985	10.4	6.8	13.9	3.9	.4	.7	.1	+	-	36.1
1986	3.1	14.0	8.1	3.8	1.1	.5	.2	.1	-	30.9

Table 3. Mean weight at age of silver hake from the Gulf of Maine -
Northern Georges Bank stock.

Year	Age								
	1	2	3	4	5	6	7	8	9+
1955	.046	.132	.200	.258	.331	.416	.530	.573	.654
1956	.038	.128	.204	.260	.326	.405	.499	.608	.699
1957	.026	.120	.193	.260	.322	.384	.453	.513	.603
1958	.045	.127	.210	.282	.341	.404	.494	.555	.628
1959	.051	.129	.190	.269	.348	.430	.521	.574	.656
1960	.064	.129	.171	.233	.320	.433	.512	.622	.696
1961	.065	.146	.186	.239	.303	.410	.516	.637	.685
1962	.069	.135	.172	.229	.303	.388	.503	.619	.752
1963	.080	.121	.176	.229	.308	.431	.573	.770	1.055
1964	.075	.123	.171	.228	.316	.456	.562	.702	.971
1965	.059	.147	.175	.233	.320	.448	.570	.744	.882
1966	.065	.144	.183	.229	.298	.427	.583	.772	.976
1967	.072	.155	.218	.266	.317	.385	.478	.744	.740
1968	.070	.161	.222	.278	.323	.387	.462	.589	.788
1969	.064	.154	.201	.291	.325	.375	.442	.506	.878
1970	.060	.118	.178	.232	.304	.392	.444	.509	.687
1971	.077	.122	.165	.211	.262	.344	.437	.524	.680
1972	.089	.195	.310	.437	.494	.588	1.006	1.078	1.259
1973	.119	.173	.262	.414	.472	.492	.943	1.026	1.151
1974	.144	.217	.270	.314	.342	.407	.594	.546	.625
1975	.102	.167	.238	.361	.484	.711	.396	1.276	1.285
1976	.102	.162	.237	.295	.422	.448	.645	-	-
1977	.120	.172	.221	.277	.403	.536	.859	.899	.995
1978	.114	.196	.232	.277	.329	.446	.659	.762	.992
1979	.140	.183	.261	.305	.351	.349	.513	1.069	-
1980	.094	.134	.164	.206	.283	.355	.292	.372	1.200
1981	.115	.147	.188	.215	.238	.305	.410	.324	.302
1982	.117	.159	.197	.271	.289	.312	.298	.267	.267
1983	.129	.175	.249	.311	.310	.431	.425	.288	.
1984	.126	.176	.242	.368	.404	.334	-	-	-
1985	.142	.200	.256	.325	.412	.610	.574	1.725	-
1986	.145	.214	.270	.376	.538	.834	.621	1.860	-

Table 4. Fitted NEFC bottom trawl survey abundance indices for the Gulf of Maine - Northern Georges Bank stock (strata 20-30, 36-40) of silver hake.

Year	Weight per tow (kg)		Number per tow	
	Spring	Autumn	Spring	Autumn
1963	-	12.85	-	73.25
1964	-	6.96	-	41.08
1965	-	5.64	-	29.42
1966	-	4.03	-	20.12
1967	-	2.82	-	14.63
1968	.12	2.52	2.53	13.27
1969	.33	2.71	5.55	15.99
1970	1.56	2.97	11.38	19.71
1971	1.01	3.21	12.67	26.37
1972	1.47	4.40	20.99	32.84
1973	1.89	4.51	24.21	32.64
1974	2.30	4.98	34.00	36.50
1975	3.61	7.08	43.70	47.26
1976	3.45	8.77	33.48	47.23
1977	2.11	7.82	21.16	43.22
1978	1.15	7.17	15.15	44.18
1979	1.28	6.64	17.81	44.27
1980	1.73	6.15	20.55	40.55
1981	1.56	5.30	20.78	37.58
1982	1.48	5.81	21.05	43.59
1983	1.51	6.75	21.78	51.80
1984	1.56	5.93	23.02	50.45
1985	2.20	8.12	36.28	70.03
1986	2.65	10.58	50.08	84.48

Table 5. Fitted mean number per tow at age for silver hake from the Gulf of Maine - Northern Georges Bank stock (strata 20-30, 36-40) from NEFC bottom trawl surveys in the spring and autumn.

Year	Age										Total		
	0	1	2	3	4	5	6	7	8	9+	0+	1+	2+
Spring													
1973	-	6.87	15.50	1.56	.19	.08	.01	-	-	-	24.21	24.21	17.34
1974	-	28.99	3.03	1.45	.33	.09	.05	.04	.01	.02	34.00	34.00	5.01
1975	-	20.08	20.44	2.59	.44	.14	.02	-	-	-	43.70	43.70	23.63
1976	-	7.16	16.04	8.69	1.01	.35	.19	.03	.01	-	33.48	33.48	26.32
1977	-	6.42	6.27	5.46	2.20	.44	.16	.16	.02	.01	21.16	21.16	14.73
1978	-	9.62	4.17	.78	.43	.10	.04	.02	-	-	15.16	15.16	5.54
1979	-	6.81	10.42	.36	.07	.04	.04	.04	.03	-	17.81	17.81	11.00
1980	-	2.82	12.78	4.38	.31	.09	.08	.06	.01	.03	20.55	20.55	17.74
1981	-	9.95	5.71	3.70	1.17	.17	.06	-	.01	-	20.78	20.78	10.83
1982	-	11.81	6.02	1.71	.81	.56	.10	.01	-	.04	21.05	21.05	9.24
1983	-	11.33	8.78	.93	.29	.31	.11	.02	-	-	21.78	21.78	10.44
1984	-	8.44	11.74	2.19	.25	.17	.17	.06	-	-	23.02	23.02	14.58
1985	-	30.30	3.17	1.81	.71	.16	.06	.08	-	-	36.28	36.28	5.99
1986	-	45.71	3.05	.91	.30	.07	.03	-	-	-	50.08	50.08	4.36
Autum													
1973	7.43	9.11	10.76	4.10	.61	.40	.15	-	-	.08	32.64	25.21	16.11
1974	24.55	4.78	3.98	2.41	.33	.29	.15	-	-	-	36.50	11.94	7.16
1975	10.93	10.37	19.11	4.53	1.42	.52	.16	.05	.18	-	47.26	36.33	25.97
1976	5.43	2.74	12.25	17.07	7.21	1.17	.91	.42	.01	.03	47.23	41.80	39.06
1977	3.32	3.78	7.56	16.30	10.25	1.67	.29	.06	-	-	43.22	39.90	36.12
1978	18.87	5.02	4.58	3.26	4.72	6.20	1.22	.11	.20	-	44.18	25.31	20.29
1979	.97	23.77	14.50	1.72	.80	.99	1.26	.21	.02	.02	44.27	43.30	19.53
1980	5.60	3.64	12.39	12.17	2.80	1.04	.85	1.56	.43	.08	40.55	34.95	31.31
1981	2.09	12.01	6.38	8.13	6.19	1.18	.45	.44	.63	.10	37.58	35.49	23.49
1982	10.07	15.17	9.06	3.34	2.80	2.70	.25	.07	.07	.07	43.59	33.52	18.35
1983	.97	28.92	19.99	.82	.40	.43	.20	.04	.01	.01	51.80	50.82	21.90
1984	17.10	12.23	15.00	4.52	1.02	.37	.20	-	-	.02	50.45	33.35	21.13
1985	28.40	32.48	3.00	4.99	1.07	.06	.01	.02	-	-	70.03	41.63	9.15
1986	9.98	60.32	4.36	7.96	1.68	.14	.03	.02	-	-	84.48	74.50	14.19

Table 6. Estimation of F in 1986 for the Gulf of Maine -
Northern Georges Bank silver hake fishery.

Year	Fitted autumn survey catch/tow (age 2+ numbers)	Total catch	Relative exploitation index ¹	Fishing mortality ²
1973	16.11	32,083	1,991	.588
1974 ⁵	7.16	20,680	2,888	.284
1975	25.97	39,874	1,535	.658
1976	39.06	13,634	349	.314
1977	36.12	12,457	345	.468
1978 ⁶	20.29	12,609	621	.775
1979	19.53	3,415	175	.186
1980	31.31	4,730	151	.405
1981	23.49	4,416	188	.390
1982	18.35	4,656	254	.368
1983	21.90	5,310	242	.361
1984	21.13	8,289	392	.456
1985	9.15	8,297	907	(.518) ^{3,4}
1986	14.19	8,502	599	(.458) ³

¹Total international catch divided by survey catch per tow index.

²Weighted mean F for fully-recruited ages.

³Calculated from power curve relationship of relative exploitation
on fishing mortality for 1973-1984:

.2883

$$Y = .0727X \quad r = .727$$

⁴Value calculated from VPA was .401.

⁵Not used in calculation of relationship because F value appeared
to be excessively low for amount of relative exploitation in
comparison to other years.

⁶Not used in calculation of relationship because F value appeared
to be excessively high for amount of relative exploitation in
comparison to other years.

Table 8. Stock size estimates (millions) for the Gulf of Maine - Northern Georges Bank silver hake stock derived from virtual population analysis (M = .40).

AGE	1955	1956	1957	1958	1959	1960	1961	1962	1963	1964	1965	1966
STOCK SIZE												
1	839.7	787.9	969.9	1159.8	1248.6	1276.6	1192.3	1015.8	1019.5	880.9	521.9	314.6
2	684.1	549.2	515.0	607.4	760.4	828.8	852.5	801.2	679.1	671.5	592.2	346.7
3	472.7	442.4	357.9	329.4	390.8	485.4	525.0	552.6	509.9	416.1	412.3	377.6
4	273.4	276.3	267.0	192.4	188.4	214.9	263.8	303.6	268.1	231.9	172.4	208.6
5	116.3	127.7	135.9	111.1	82.8	82.8	101.3	135.3	105.8	97.6	58.2	72.3
6	51.6	53.5	64.3	57.8	51.6	34.1	38.8	52.7	52.9	47.5	25.8	24.4
7	26.3	23.6	27.7	28.7	24.9	24.3	15.8	19.6	25.3	27.1	15.4	11.4
8	17.9	12.4	12.4	13.2	14.7	11.7	12.5	7.3	8.4	13.2	8.9	7.1
9+	8.1	5.9	5.2	5.7	5.0	4.6	5.3	3.3	4.4	5.0	4.8	4.1
TOT NOS	2490.1	2279.0	2355.5	2505.6	2767.3	2963.3	3007.2	2891.4	2673.3	2390.7	1812.0	1366.7
SPWN NOS	1346.3	1243.7	1156.5	1080.3	1187.4	1322.6	1439.2	1519.5	1349.8	1213.7	1026.7	891.2
AGE	1967	1968	1969	1970	1971	1972	1973	1974	1975	1976	1977	1978
1	323.3	325.3	272.0	185.3	256.0	428.0	353.2	380.0	170.9	55.9	44.3	91.1
2	206.6	216.4	217.4	179.8	104.2	168.4	223.8	209.7	237.1	107.5	36.1	28.2
3	215.9	134.2	141.8	137.1	107.6	50.3	77.1	77.2	115.0	110.7	56.6	17.2
4	186.6	118.5	69.1	81.5	65.8	15.0	19.2	32.3	33.8	27.2	54.4	19.9
5	83.1	81.1	40.1	29.3	27.5	6.0	6.7	9.2	14.3	6.8	11.3	24.5
6	32.6	39.4	25.4	14.0	9.0	3.2	2.3	3.0	4.0	3.4	2.2	5.2
7	11.1	17.6	15.5	9.8	3.8	.6	1.6	1.2	1.2	.9	1.2	1.1
8	5.0	5.5	7.8	6.4	3.1	.3	.3	1.0	.5	-	-	.7
9+	2.3	2.6	4.1	2.3	1.3	1.0	.5	1.0	1.0	-	-	-
TOT NOS	1066.5	940.5	793.0	645.4	578.2	672.9	684.7	714.7	577.9	312.3	206.0	187.9
SPWN NOS	647.7	519.8	424.9	379.5	274.2	173.3	235.9	244.9	304.0	206.8	144.2	84.3
AGE	1979	1980	1981	1982	1983	1984	1985	1986	1987			
1	76.4	50.6	60.4	91.5	119.5	74.8	80.8	(230) ¹	(120) ²			
2	58.9	50.7	33.0	36.5	56.6	78.0	47.7	45.8	151.7			
3	12.3	36.6	24.5	15.4	16.6	26.6	35.1	26.5	19.5			
4	5.9	6.4	14.9	10.5	8.0	7.9	10.0	12.4	11.3			
5	4.9	2.8	2.7	6.8	4.6	3.9	2.9	3.6	5.3			
6	5.8	1.8	1.5	1.3	2.8	1.7	1.8	1.6	1.5			
7	1.6	2.1	.8	.8	.8	-	.6	.7	.7			
8	-	.7	.7	.4	.4	-	-	.3	.3			
9+	-	-	-	.4	-	-	-	-	.1			
TOT NOS	165.7	151.7	138.5	163.6	209.3	193.0	178.9	320.9	310.4			
SPWN NOS	64.5	78.5	63.3	56.3	65.7	84.9	76.8	70.8	127.2			

¹Estimated (see Table 10).²Mean 1981-1985 year-class size.

Table 9. Stock biomass estimates (000's mt) for the Gulf of Maine - Northern Georges Bank silver hake stock derived from virtual population analysis (M = .40).

AGE	1955	1956	1957	1958	1959	1960	1961	1962	1963	1964	1965	1966
STOCK BIOMASS AT AGE												
1	38.6	29.9	25.2	52.2	63.7	81.7	77.5	70.1	81.6	66.1	30.8	20.4
2	90.3	70.3	61.8	77.1	98.1	106.9	124.5	108.2	82.2	82.6	87.1	49.9
3	94.5	90.3	69.1	69.2	74.3	83.0	97.6	95.1	89.7	71.2	72.2	69.1
4	70.5	71.8	69.4	54.3	50.7	50.1	63.1	69.5	61.4	52.9	40.2	47.8
5	38.5	41.6	43.8	37.9	28.8	26.5	30.7	41.0	32.6	30.8	18.6	21.5
6	21.5	21.7	24.7	23.3	22.2	14.8	15.9	20.4	22.8	21.6	11.6	10.4
7	14.0	11.8	12.6	14.2	13.0	12.5	8.1	9.8	14.5	15.2	8.8	6.6
8	10.2	7.6	6.4	7.3	8.4	7.3	8.0	4.5	6.5	9.3	6.6	5.5
9+	5.3	4.1	3.1	3.6	3.3	3.2	3.6	2.5	4.6	4.8	4.3	4.0
TOT WGT	383.5	349.1	316.1	339.1	362.5	385.9	429.0	421.1	395.7	354.5	280.1	235.4
SPWN WGT	303.1	285.8	262.0	251.8	254.9	256.2	295.6	301.9	276.0	251.0	210.0	191.0
AGE	1967	1968	1969	1970	1971	1972	1973	1974	1975	1976	1977	1978
1	23.3	22.8	17.4	11.1	19.7	38.1	42.0	54.7	17.4	5.7	5.3	10.4
2	32.0	34.8	33.5	21.2	12.7	32.8	38.7	45.5	39.6	17.4	6.2	5.5
3	47.1	29.8	28.5	24.4	17.8	15.6	20.2	20.9	27.4	26.2	12.5	4.0
4	49.6	32.9	20.1	18.9	13.9	6.6	7.9	10.2	12.2	8.0	15.1	5.5
5	26.3	26.2	13.0	8.9	7.2	3.0	3.2	3.2	6.9	2.9	4.5	8.1
6	12.5	15.2	9.5	5.5	3.1	1.9	1.1	1.2	2.9	1.5	1.2	2.3
7	5.3	8.1	6.8	4.3	1.7	.6	1.5	.7	.5	.6	1.1	.7
8	3.7	3.3	3.9	3.2	1.6	.4	.3	.5	.6	-	-	.5
9+	1.7	2.1	3.6	1.6	.9	1.3	.6	.6	1.3	-	-	-
TOT WGT	201.6	175.2	136.4	99.2	78.5	100.2	115.6	137.5	108.8	62.3	45.9	37.0
SPWN WGT	162.8	136.6	103.8	78.1	52.7	47.9	56.6	63.1	73.7	48.2	37.4	24.2
AGE	1979	1980	1981	1982	1983	1984	1985	1986	1987			
1	10.7	4.8	6.9	10.7	15.4	9.4	11.5	33.3	17.4			
2	10.8	6.8	4.9	5.8	9.9	13.7	9.5	9.8	32.5			
3	3.2	6.0	4.6	3.0	4.1	6.4	9.0	7.2	5.3			
4	1.8	1.3	3.2	2.8	2.5	2.9	3.3	4.7	4.2			
5	1.7	.8	.6	2.0	1.4	1.6	1.2	1.9	2.8			
6	2.0	.6	.5	.4	1.2	.6	1.1	1.4	1.3			
7	.8	.6	.3	.2	.3	-	.3	.4	.4			
8	-	.3	.2	.1	.1	-	-	.6	.5			
9+	-	-	-	.1	-	-	-	-	-			
TOT WGT	31.0	21.2	21.3	25.2	35.0	34.7	35.9	59.3	64.4			
SPWN WGT	15.7	13.3	12.1	12.0	15.3	19.3	20.1	21.6	33.5			

Table 10. Relationship between fitted survey catch per tow at age 1 (numbers) and year-class size at age 1 (millions) from VPA for the Gulf of Maine - Northern Georges Bank silver hake stock.

Year class	Spring survey Age 1	Stock size Age 1
1974	20.08	170.9
1975	7.16	55.9
1976	6.42	44.3
1977	9.62	91.1
1978	6.81	76.4
1979	2.82	50.6
1980	9.95	60.4
1981	11.81	91.5
1982	11.33	119.5
1983	8.44	74.8
1984 ²	30.30	80.8
1985	45.71	(230.7) ¹

¹Calculated from a power curve relationship of spring survey number per tow on VPA year-class size for 1974-1983:

$$Y = 19.1613X^{.6510}, \quad r = .806$$

²Not used in relationship.

Table 11. Projected catch (age 1+) in 1987 from the Gulf of Maine - Northern Georges Bank stock of silver hake with fishing mortality (F) ranging from .05 to .60, under two options of recruitment in 1987. Resulting stock size (age 2+) in 1988 and the percentage change (by weight) from 1987 are also given.

F	Recruits in 1987 = 90 million			Recruits in 1987 = 120 million		
	1987 Catch	1988 Stock	% change in stock from 1987	1987 Catch	1988 Stock	% change in stock from 1987
0.05	1.9	52.2	10.6	1.9	56.5	19.7
0.10	3.8	50.2	6.4	3.8	54.5	15.5
0.15	5.5	48.4	2.5	5.5	52.7	11.7
0.20	7.2	46.6	-1.3	7.2	50.9	7.8
0.25	8.8	45.0	-4.7	8.8	49.2	4.2
0.30	10.3	43.4	-8.1	10.4	47.6	0.8
0.35	11.8	41.8	-11.4	11.8	46.1	-2.3
0.40	13.2	40.4	-14.4	13.2	44.6	-5.5
0.44 ¹	14.2	39.2	-16.9	14.3	43.5	-7.8
0.45	14.5	39.0	-17.4	14.6	43.2	-8.5
0.50	15.8	37.7	-20.1	15.9	41.9	-11.2
0.55	17.0	36.5	-22.7	17.1	40.7	-13.8
0.60	18.2	35.3	-25.2	18.3	39.5	-16.3

¹F_{0.1}

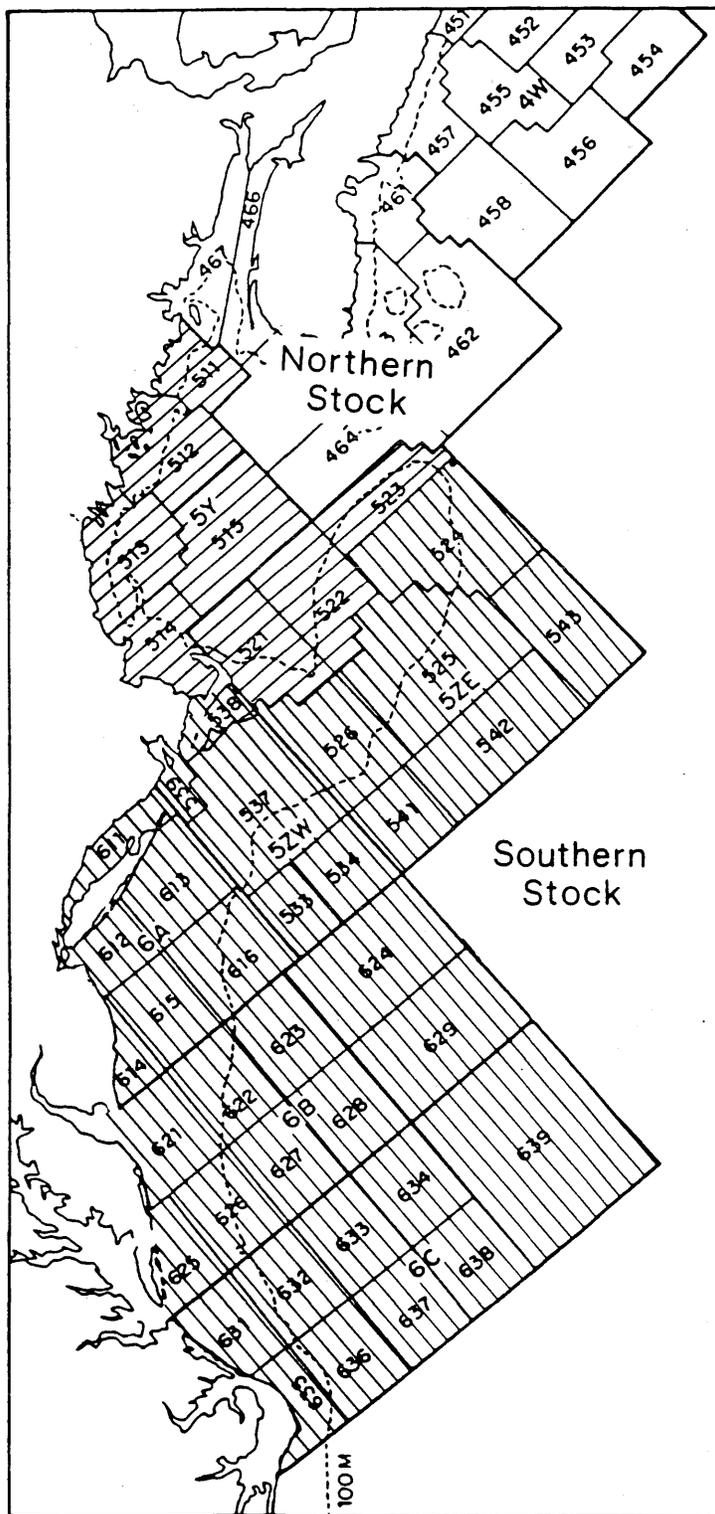


Figure 1. Stock definition of silver hake and fishery statistical areas (SA) off the northeast coast of the United States. Northern stock inhabits SA 511-515 and 521-523; the southern stock occupies areas 524-526, 537-539 and 600+.

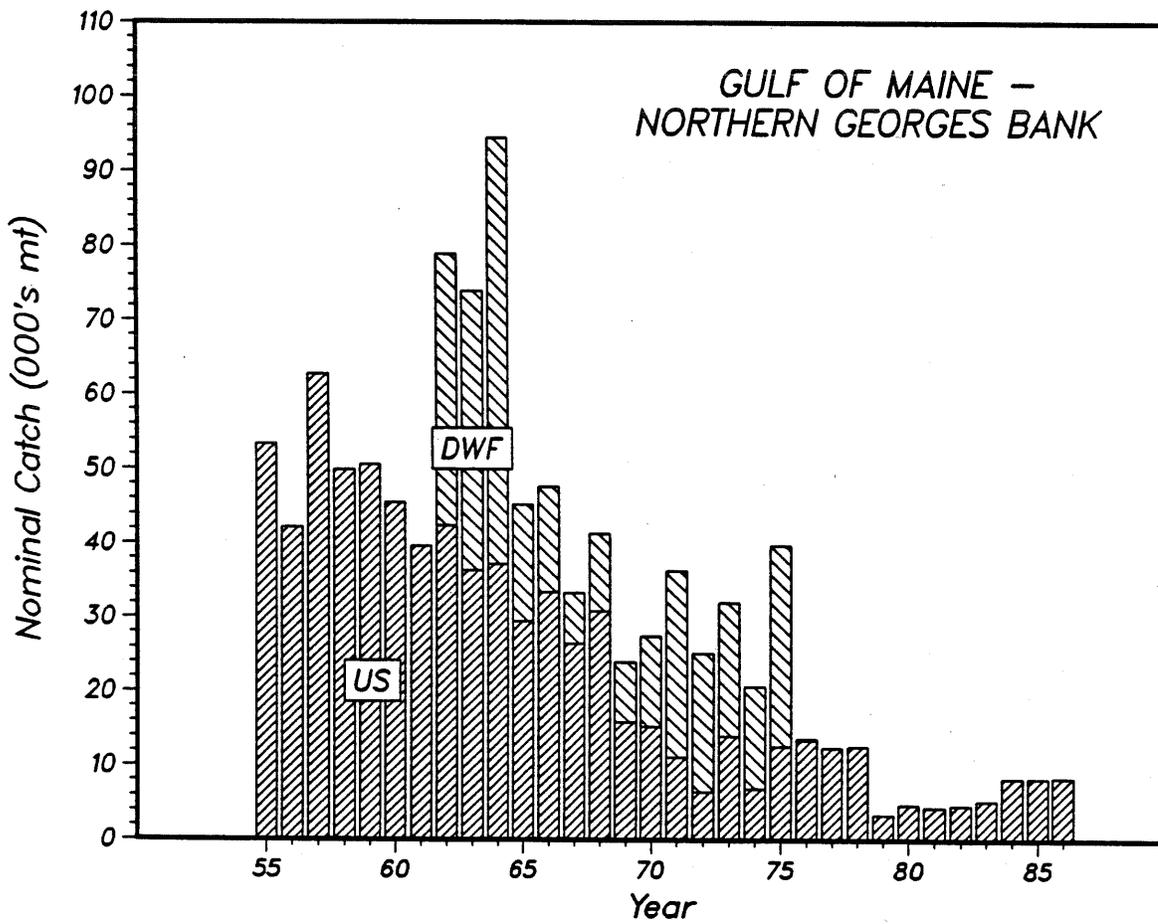


Figure 2. US commercial, and distant-water-fleet components of the total catch from the Gulf of Maine - Northern Georges Bank silver hake stock.

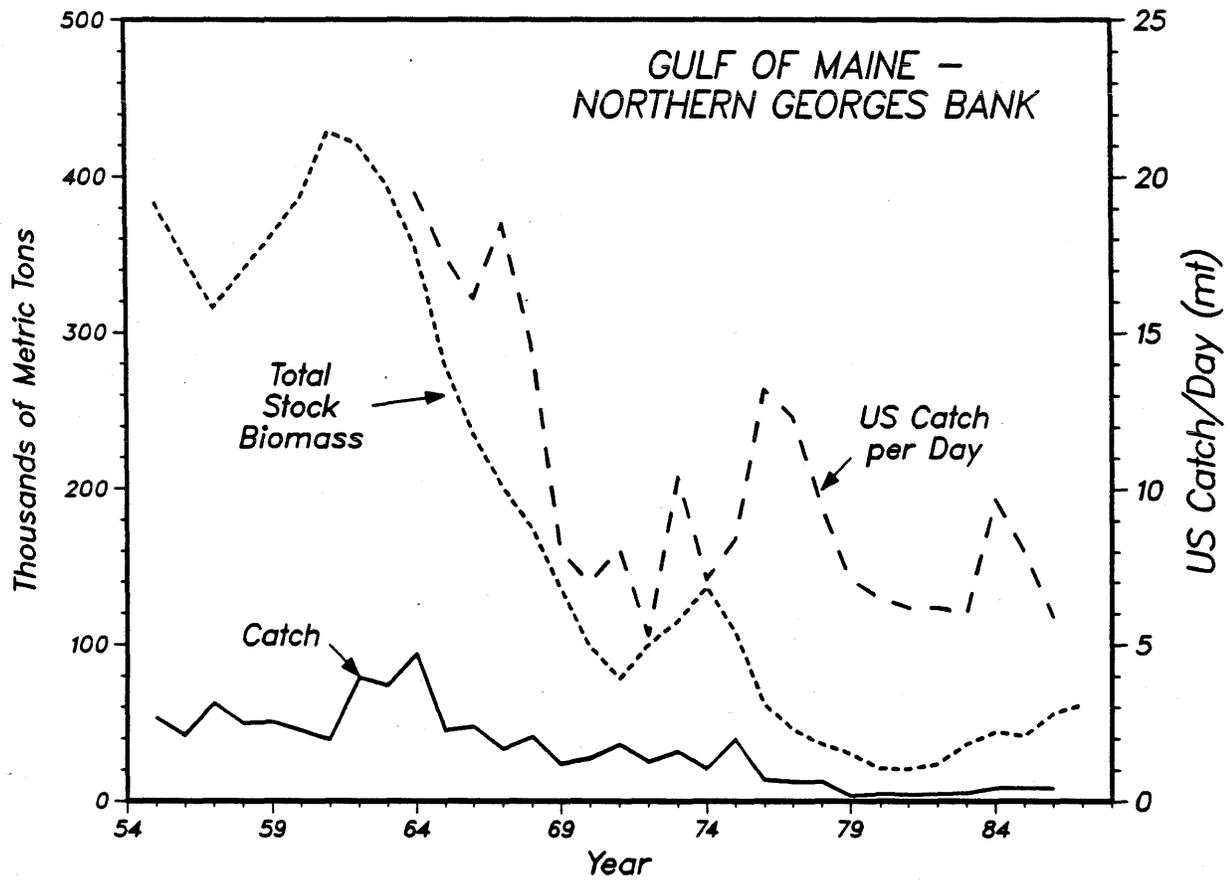


Figure 3. International catch, stock biomass (age 1+) from VPA, and commercial catch/day from the Gulf of Maine - Northern Georges Bank silver hake stock.

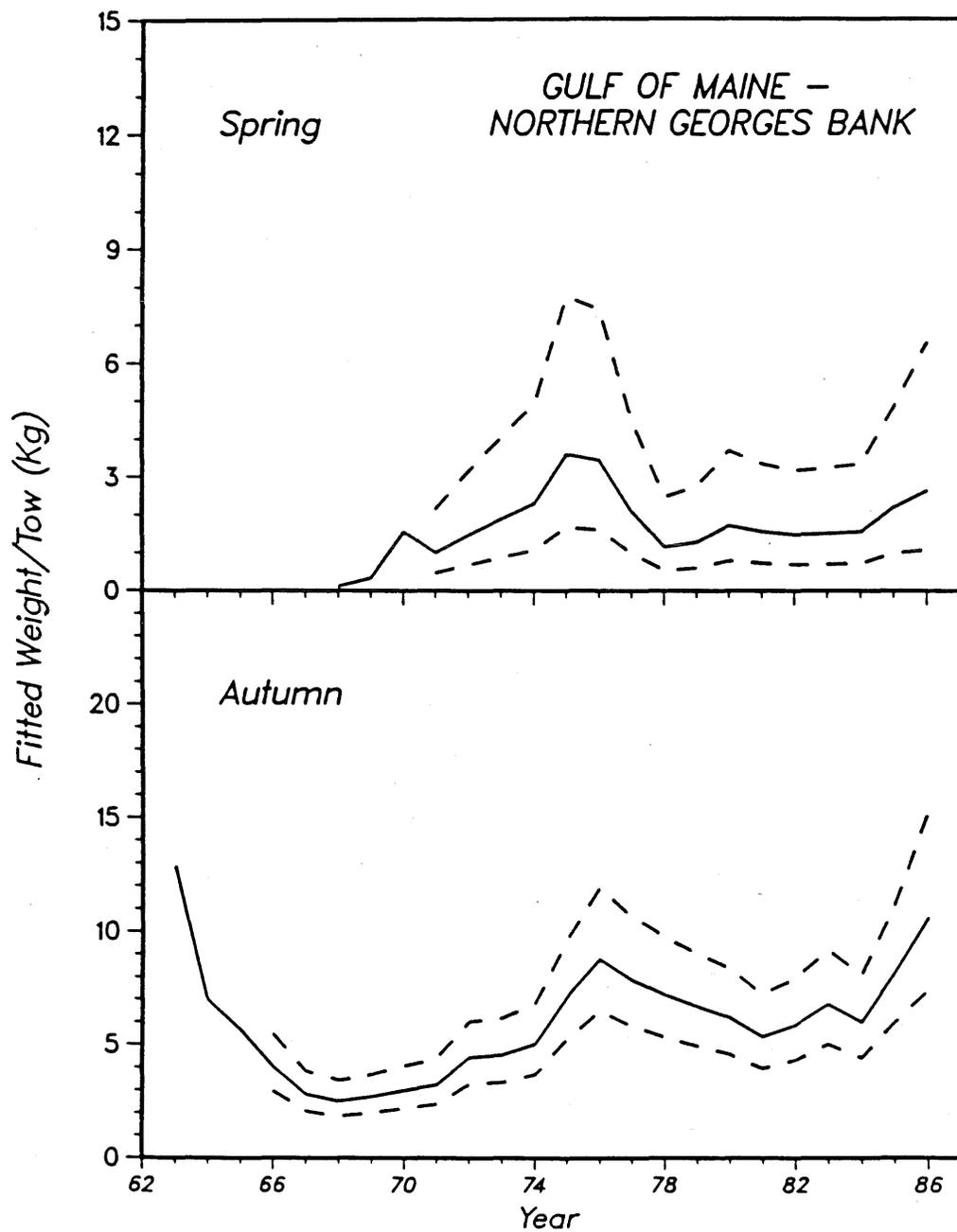


Figure 4. Fitted weight-per-tow indices from spring and autumn NEFC bottom trawl surveys during 1963-1986 with 80% confidence intervals.

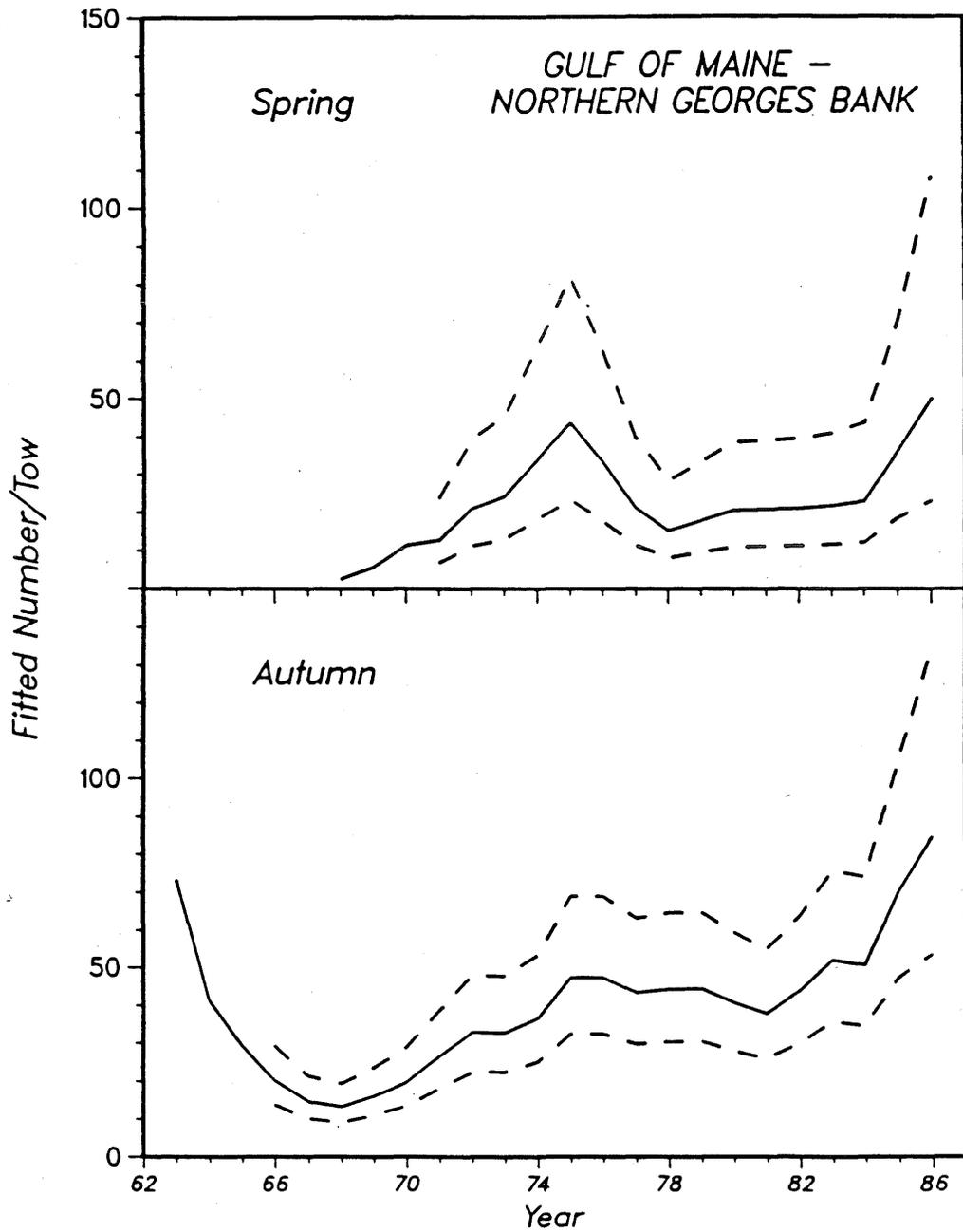


Figure 5. Fitted number-per-tow indices from spring and autumn NEFC bottom trawl surveys during 1963-1986 with 80% confidence intervals.

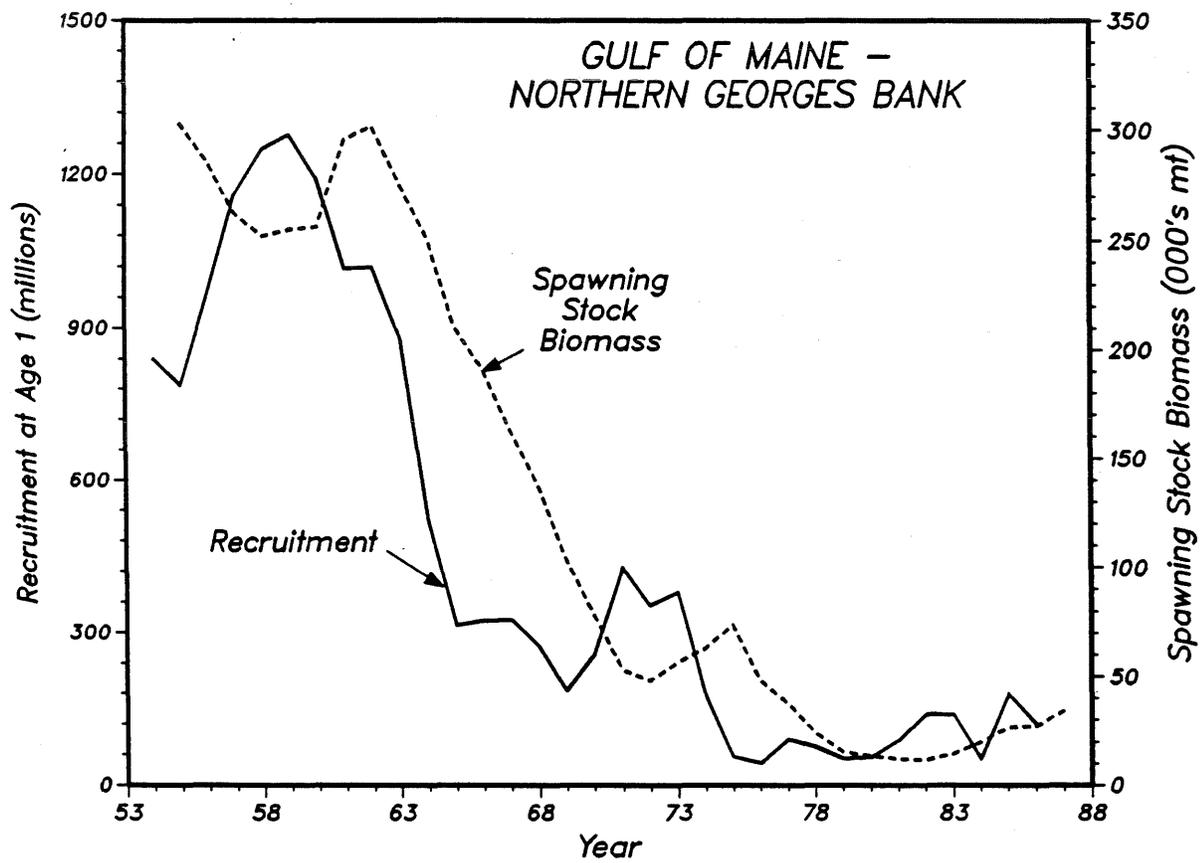


Figure 6. Spawning stock biomass during 1955-1987 and abundance at age 1 of the 1954-1986 year classes from VPA.

SOUTHERN GEORGES BANK - MIDDLE ATLANTIC STOCK**Catch History**

Total catches from the Southern Georges Bank - Middle Atlantic stock of silver hake for 1955-1986 are presented in Table 12. Catches from this stock averaged 14,600 mt during 1955-1961 before increasing sharply to 307,100 mt in 1965, followed by a steady decline to 27,500 mt in 1970. During 1973-1975, catches averaged 103,000 mt but declined again through 1980 and have averaged 13,100 mt during 1980-1986 (Figure 7). The 1986 catch was 10,123 mt.

US commercial catches (Table 12 and Figure 7) averaged 12,700 mt during 1955-1962, increased sharply to 25,000 mt in 1964, but declined steadily after 1965 to a series low of 5,200 mt by 1971. A period of generally increasing catches followed, with levels reaching 13,100 mt in 1979. Catches were very steady from 1980-1985, averaging 11,900 mt. In 1986, the reported catch declined to 9,479 mt.

Estimates of the US recreational catch in 1960, 1965, 1970, 1974-1977, 1979-1985 were obtained from marine angler surveys (Type A only, i.e. fish that were brought ashore in whole form and were available for identification, enumeration, weighing and measuring by Marine Recreational Survey interviewers). Catches prior to 1979 were assumed to be over-estimated by 100% based on a study of marine angler recall (Hiett and Worral 1977) and the fact that the recall period in the early surveys was 12 months. In surveys beginning in 1979, the recall period was reduced to 3 months. Ratios between recreational and US commercial catch during 1960-1977 were fairly constant in 1965 (0.061), 1970 (0.074), 1974 (0.075), and 1976 (0.089); the 1960 ratio was somewhat higher at 0.108 the 1977 ratio was much higher (0.208), while the

1975 and 1979 ratios were lower (0.012 and 0.031, respectively). The ratios during the 1981-1985 were consistently lower than those prior to 1977 averaging only 0.010 per year. Estimates of catches in each of the remaining years were obtained by applying these ratios to the commercial catch. The 1960 ratio was applied to the commercial catches in 1955-1959 and 1961-1962; the 1965 ratio to the 1963-1964, and 1966-1967 catches; and the 1970 ratio to the 1968-1969 and 1971-1973 catches. The 1981-1985 average was used to estimate the 1986 catch. Recreational catches have generally been a minor component of the total catch, averaging about 777 mts per year and ranging from 0 to 1,974 mt (Table 12 and Figure 8). The 1986 recreational catch was estimated to be 94 mt.

The distant water fleet began reporting catches from the Southern Georges Bank - Middle Atlantic area in 1962. Countries that have participated in this fishery include Bulgaria, Cuba, the Federal Republic of Germany (FRG), the German Democratic Republic (GDR), Ireland, Italy, Japan, Mexico, Poland, Romania, Spain, and the USSR, with the USSR catch clearly dominating until 1978. The DWF catch in 1962 was 5,300 mt (27% of the total) taken by the USSR (Table 12 and Figure 8). This catch rapidly increased to a high of 283,400 mt by 1965 (92% of the total in that year), but declined steadily to 20,600 mt in 1970. Catches then increased to 102,000 mt by 1974 but declined again to 47,900 mt in 1977. Since 1979, DWF catches have averaged about 1,900 mt. The 1986 DWF catch was 550 mt.

Commercial Catch Composition

Estimated commercial catches at age (in numbers) for 1955-1986 are given in Table 13. The data indicate that during the 1950's and 1960's, the catch

was made up predominantly of 2-4 year old fish (average of about 86% of the total each year). In the early 1970's the trend was toward younger, age 1-3 fish, the result of several strong year classes recruiting to the fishery in those years. During 1975 to about 1978, approximately 90% of the catch was age 2-4 however, since 1979 the catch has been made up primarily of age 2-3 fish (about 65% of the total each year).

Mean weights (kg) at age for 1955-1986, given in Table 14, were calculated utilizing the method described for the Gulf of Maine - Northern Georges Bank (Northern) stock.

Abundance Indices

Commercial Catch per Effort

The commercial catch-per-effort index (US days fished) was calculated utilizing tonnage class 2 and 3 US otter trawlers from trips in which silver hake were assumed to be the main species sought.

The catch-per-day index has ranged from a high of 13.3 mt/day in 1966 to a low of 2.5 mt/day in 1971 (Table 12 and Figure 8). The index declined steadily from high levels in the mid 1960's to a low in 1971 before increasing until 1978. After declines in 1979 and 1980, the index rose sharply in during 1981-1982, but has generally declined through 1986. During 1964 through about 1972, this index was reasonably consistent with changes in stock biomass calculated from VPA (Figure 9), however, steady increases in the index during the most recent years have not been reflected in either research vessel bottom trawl survey indices nor in VPA results.

Research Vessel Mean Catch per Tow

Spring and autumn bottom trawl survey indices were calculated the same as in the Northern stock, but using inshore/offshore data combined and the #36 Yankee trawl as the standard gear. Surveys which used the #36 Yankee trawl but did not include inshore strata (spring 1968-1972 and autumn 1963-1973) were adjusted using ratios of 0.950 and 0.960:1 for spring, and 0.869 and 0.890:1 for autumn surveys, for weight and numbers, respectively. These ratios were calculated by comparing offshore indices with combined inshore/offshore indices in those years from which both inshore and offshore surveys were conducted (spring 1976-1981 and autumn 1974-1981). Surveys which used the #41 Yankee trawl and did not sample inshore strata (spring 1973-1975) were adjusted using ratios of 0.380 and 0.320:1, for weight and numbers, respectively. These correction factors resulted from combining inshore/offshore ratios with values obtained from intervention analysis.

The spring survey fitted weight-per-tow index (Table 15 and Figure 9) decreased from 2.7 kg in 1968 to 1.7 kg in 1970 before increasing to 2.9 kg in 1975. The index then followed a generally declining trend until it reached a low of 1.7 kg in 1983 before increasing to 2.2 kg in 1986. Catch per tow in numbers (Table 15 and Figure 10) decreased from 24.9 in 1968 to 17.6 in 1972. The index then rose and averaged 23.7 during 1974-1975 but declined steadily, to a low of 10.0 in 1982. Since 1982, the index has increased each year to 15.6 in 1986.

The fitted autumn weight-per-tow index (Table 15 and Figure 9) decreased from its highest levels during 1963-1965 (average 3.7 kg) to 1.4 kg in 1970, increased briefly during 1971-1972 then decreased through 1974. The index then increased to 1.9 kg in 1978 before declining steadily to 1.4 kg in 1981.

During 1981-1985, the index generally increased to 2.1 kg in 1985. The index decreased to 1.6 kg in 1986. Catch per tow in numbers (Table 15 and Figure 10) during the autumn, was relatively stable during 1963-1973, averaging 39.2, before increasing to 82.4 in 1977. The index has generally declined since 1977 to 40.9 in 1986.

Coefficients of variation for this stock averaged 0.18 and 0.21 for the spring and autumn weight-per-tow surveys, respectively. Average CV's for the mean number-per-tow indices were 0.20 and 0.32 for the spring and autumn surveys, respectively (Appendix Tables 4 and 5). As with the Northern stock, these CV's are in general agreement when compared with other demersal species sampled in the NEFC bottom trawl survey.

Mean Catch per Tow at Age

Mean catch per tow at age (numbers) for 1973-1986 from spring and autumn bottom trawl surveys are given in Table 16. Ages ranged between 1 and 10 in both the spring and autumn surveys, however individuals older than about age 8 were seldom encountered (ages 9+ are combined in the Table). Year-class success in this stock has been similar to that in the Northern stock. The 1973-1974 year classes were quite strong while 1975-1976 were weak in comparison to other years. The 1977 cohort appeared to be strong (although not as strong as 1974), while 1978-1981 were only average in strength. The 1982 year class was strong while 1983 appeared quite weak in comparison. The 1984-1985 year classes appear to be quite strong while the 1986 cohort may be weak, with the lowest autumn age 0 index in the time series.

Fishing Mortality

Fishing mortality (F) for fully recruited ages in 1986 was estimated from a power curve regression between fishing mortality from VPA and relative exploitation (calculated as total international catch divided by the fitted autumn survey number-per-tow index for ages 2 and older). Terminal F in 1986 was also selected using an iterative process consisting of alternate computations of VPA and the F-exploitation regression until the F value predicted from the regression and the terminal F in the VPA reached convergence. This process resulted in an F for 1986 of 0.33 ($r=0.779$, $p<0.01$) for ages 2 and older (Table 17).

Fishing mortalities for fully recruited ages from VPA ranged from 0.09 to 0.98 during 1955-1986 and averaged 0.45 (Table 18). During 1955-1959 F averaged 0.32 but dropped to 0.11 during 1960-1962 before rising dramatically with the introduction of the DWF to 0.98 in 1965. F then dropped and averaged 0.52 during 1968-1977. With the inception of MFCMA and the restrictions placed on the foreign fishery, F dropped from 0.76 in 1977 to 0.31 in 1980, increased during 1981-1984, and averaged 0.36 in 1985-1986.

Recruitment

Recruitment of the 1954-1984 year classes estimated from VPA have ranged from 115 million fish (1979 year class) to 4.3 billion fish (1962 year class) with a mean size of 1.0 billion and a median of 535 million (Table 19 and Figure 11). Every year class since 1973 has fallen below the mean, and every year class since 1974 below the median. An estimate of the 1985 year class was obtained through a power curve regression between the fitted spring survey catch-per-tow-at-age 1 index and year-class size at age 1 from VPA. The

regression produced a correlation of 0.755 ($p=0.009$) (Table 21), and an estimate of year-class size of approximately 200 million fish.

Recruitment to this stock increased from an average of 444 million during 1954-1956 before increasing steadily to 4.3 billion in 1963. Heavy fishing pressure in the mid 1960's decreased spawning stock biomass and subsequent year-class sizes steadily to 487 million in 1968. The 1968-1969 cohorts were also weak in comparison to earlier years, but recruitment increased sharply and averaged 1.3 billion fish for the 1970-1973 year classes. Since 1975, year-class strength has averaged 194 million.

Stock Biomass

Annual stock biomass values for 1955-1987 were obtained by applying mean weights at age (Table 14) to age specific stock size estimates (in millions) from VPA. Total stock biomass (age 1+) increased from 81,100 mt in 1955 to a high of 960,500 mt in 1964, then declined steadily in response to heavy fishing pressure to 190,400 mt in 1970 (Table 20 and Figure 8). Biomass then increased to average 365,500 mt during 1972-1975, but then declined to a series low of only 46,200 mt in 1981 (a factor of 21 less than the series high in 1963). Since 1981, total biomass has increased but remained at a low level, with an estimated 58,200 mt available at the beginning of 1987.

Spawning stock biomass increased from 51,600 mt in 1955 to a series high of 655,700 mt in 1965 before dropping steadily to 143,000 mt in 1970 (Table 20 and Figure 11). Biomass then increased to 219,500 mt in 1974 but subsequently declined to only 24,200 mt in 1983, but has increased since then to an estimated 35,300 mt in 1987.

Partial Recruitment

Silver hake were generally fully recruited to the commercial fishery by age 3 during 1955-1971, but shifted to age 2 during 1972-1986. Partial recruitment in 1986, the ratio between F at a given age and the mean F for fully recruited ages, was estimated to be 21% at age 1 and 100% at ages 2 and older. These estimates were used in the projections of catch and stock size for 1987-1989.

Yield Per Recruit

Yield-per-recruit analysis performed on this stock resulted in a value of $F_{0.1}$ equal to 0.35 and F_{max} greater than 2.00. Partial recruitment and weight-at-age data used in the analysis were average values for 1979-1986, reflecting conditions in the fishery during the most recent period of exploitation.

Catch and Stock Size Projections

Projections of catch in 1987 and stock size in 1988 were calculated assuming recruitment of 200 million fish in 1987, the mean level during both the last 5 and 10 year periods. Fishing mortality values ranging from 0.05 to 0.60 were also considered. The results of the catch and stock size projections are given in Table 22.

Assuming recruitment into the fishery in 1987 is about 200 million fish, fishing at $F_{0.1}$ would result in a catch of about 11,500 mt, and would leave an age 2+ biomass of 43,700 mt in 1988, approximately a 2% increase from 1987 (Table 11). A catch of 12,600 mt in 1987, requiring an F of 0.39, would leave age 2+ biomass unchanged from 1987 to 1988.

LITERATURE CITED

- Almeida, F.P. 1987. Stock definition of silver hake in the New England - Middle Atlantic area. N. Amer. Jour. Fish. Mgmt. (In press)
- Almeida, F.P. and E.D. Anderson. 1981. Status of the silver hake resource of the northeast coast of the United States - 1981. NMFS, NEFC, Woods Hole Laboratory Reference Document 81-36. 78p.
- Almeida, F.P., M.J. Fogarty, S.H. Clark, and J.S. Idoine. 1986. An evaluation of precision of abundance estimates derived from Bottom trawl surveys off the northeastern United States. ICES C.M. 1986/G:91 19p.
- Conservation and Utilization Division. 1986. NEFC Bottom Trawl Evaluation Program - Status Report. Unpublished report to the Center Director. 64p.
- Fogarty, M.J., J.S. Idoine, F.P. Almeida, and M. Pennington. 1986. Modelling trends in abundance based on research vessel surveys. ICES C.M. 1986/G:92. 13p.
- Hiett, R.K. and J.W. Worrall. 1977. Marine recreational fishermen's ability to estimate catch and to recall catch and effort over time. Human Sciences Research, Inc., Westgate Research Park, McLean, VA, HS-RR-77/13-Cd. 22p.
- Morse, W.W. 1979. An analysis of maturity observations of 12 groundfish species collected from Cape Hatteras, North Carolina to Nova Scotia in 1977. NMFS, NEFC, Sandy Hook Laboratory Report No. 79-32. 20p.
- Pennington, M.R. 1983. Efficient estimators of abundance for fish and plankton surveys. Biometrics, 39:281-286.
- Thompson, W.F., and F.H. Bell. 1934. Biological statistics of the Pacific halibut fishery. 2. Effect of changes in intensity upon total yield and yield per unit of gear. Rep. Int. Fish. (Pacific Halibut) Comm. 8:49p.

Table 12. Silver hake catches (mt) from the Southern Georges Bank - Middle Atlantic stock.

Year	Bulgaria	Cuba	GDR	Italy	Japan	Mexico	Poland	Romania	Spain	USSR	Other ¹	USA Comm.	USA Rec.	Total	USA catch/day
1955	-	-	-	-	-	-	-	-	-	-	-	12,489	1,353	15,717	-
1956	-	-	-	-	-	-	-	-	-	-	-	13,417	1,454	16,564	-
1957	-	-	-	-	-	-	-	-	-	-	-	15,476	1,677	17,153	-
1958	-	-	-	-	-	-	-	-	-	-	-	12,156	1,317	13,473	-
1959	-	-	-	-	-	-	-	-	-	-	-	15,439	1,673	17,112	-
1960	-	-	-	-	-	-	-	-	-	-	-	8,306	900 ²	9,206	-
1961	-	-	-	-	-	-	-	-	-	-	-	11,918	1,291	13,209	-
1962	-	-	-	-	-	-	-	-	-	5,325	-	12,097	1,311	18,733	-
1963	-	-	-	-	-	-	-	-	-	74,023	-	18,252	1,107	93,382	-
1964	-	-	-	-	-	-	-	-	-	127,036	-	25,030	1,518	153,584	8.92
1965	-	-	-	-	-	-	-	-	-	283,366	-	22,406	1,359 ²	307,131	13.26
1966	-	-	-	-	-	-	-	-	-	200,058	-	10,571	641	211,270	13.31
1967	-	-	-	-	38	-	-	-	-	81,711	-	8,957	543	91,249	4.56
1968	-	-	-	-	82	-	948	-	-	48,392	-	8,447	627	58,496	4.37
1969	746	-	6	-	252	-	235	6	-	66,151	-	7,601	564	75,561	4.10
1970	439	-	-	-	325	-	4	103	-	19,762	-	6,404	475 ²	27,512	6.20
1971	721	146	-	-	107	-	36	432	-	64,902	-	5,163	383	71,890	2.53
1972	1,806	828	42	-	204	-	-	127	-	85,416	-	5,561	412	94,396	5.56
1973	1,502	-	50	-	438	-	343	49	-	95,606	1	6,146	458	104,593	3.86
1974	2,471	-	11	-	107	-	113	194	-	99,215	1	7,213	538 ²	109,863	4.39
1975	1,917	212	8	-	1	-	26	-	22	63,425	201	8,342	99 ²	74,253	5.08
1976	33	3,750	1	-	14	-	211	586	5	53,707	-	9,581	853 ²	68,741	6.40
1977	1,052	269	-	60	59	-	2	-	103	46,305	-	9,484	1,974 ²	59,308	7.37
1978	-	-	-	612	274	4	-	-	73	13,390	-	11,410	1,369	27,132	9.77
1979	-	-	-	600	696	110	-	16	380	3,075	-	13,087	411 ²	18,375	7.85
1980	-	73	-	502	607	39	1	-	476	-	-	11,731	117 ²	13,546	7.19
1981	-	-	-	1,705	641	-	48	-	649	-	-	11,718	65 ²	14,826	10.27
1982	-	-	-	1,128	480	-	-	-	789	-	-	11,908	256 ²	14,561	13.07
1983	-	-	-	334	116	-	-	-	170	-	-	11,520	+ ²	12,140	10.03
1984	-	-	-	208	47	-	-	-	157	-	-	12,731	+ ²	13,143	11.55
1985	-	-	16	938	42	-	15	-	310	-	-	11,820	23 ²	13,164	6.80
1986	-	-	13	333	3	-	-	-	201	-	-	9,479	94 ²	10,123	7.21

¹Includes FRG (1973-1974) and Ireland (1975).

²From marine angler surveys, Type A catch only (+ denotes less than 30,000 fish); remaining years are estimated (see text).

Table 13. Commercial catch at age (millions of fish) of silver hake from the Southern Georges Bank - Middle Atlantic stock (+ denotes less than .1 million).

Year	Age									Total
	1	2	3	4	5	6	7	8	9+	
1955	17.4	9.6	20.0	21.7	8.7	1.9	.7	.3	.1	80.3
1956	61.9	46.6	20.4	15.2	5.4	1.3	.7	.2	.1	151.7
1957	2.4	22.2	31.3	22.6	9.6	2.6	1.0	.3	.1	92.0
1958	20.6	27.8	24.8	15.5	5.4	1.4	.7	.2	-	96.3
1959	11.8	11.4	36.6	24.7	8.7	2.0	.7	.2	-	96.0
1960	12.0	17.0	12.7	10.6	4.9	1.6	.9	.4	.1	60.2
1961	.4	6.2	26.2	21.5	5.5	1.5	1.0	.3	.2	62.7
1962	.5	6.6	31.7	34.6	10.1	2.0	1.4	.6	.3	87.8
1963	6.5	33.8	171.7	196.2	53.5	8.2	2.5	1.2	.5	474.1
1964	18.4	65.3	286.8	271.5	85.1	19.5	9.5	4.6	1.9	762.6
1965	46.9	203.7	901.7	553.0	75.1	16.1	7.3	2.4	.8	1806.9
1966	18.7	359.8	507.6	289.7	77.8	25.1	10.9	5.0	1.2	1295.7
1967	15.7	121.5	216.3	154.9	30.8	7.3	3.0	1.5	.3	551.5
1968	9.7	24.5	143.4	90.8	29.0	11.1	4.4	1.4	.8	315.1
1969	1.8	20.0	111.0	100.6	40.7	11.4	10.3	4.2	2.6	302.6
1970	41.8	25.1	17.3	32.6	23.1	6.5	5.0	2.8	1.3	155.4
1971	8.0	41.3	92.3	79.0	44.4	18.7	12.3	11.1	8.0	315.1
1972	134.0	174.1	111.9	33.0	5.0	2.1	.5	.1	.1	460.8
1973	72.8	325.0	112.9	29.3	4.9	1.1	.5	.1	-	546.4
1974	73.7	223.3	141.2	74.1	17.2	6.0	3.5	1.7	.5	541.2
1975	5.5	106.6	149.3	51.0	19.8	2.7	.2	.1	1.0	336.1
1976	7.6	86.6	142.8	95.2	10.4	1.3	.2	-	-	344.1
1977	2.6	34.0	132.6	68.8	11.2	3.1	2.2	.3	-	254.8
1978	2.2	26.7	20.4	28.0	12.5	2.5	.8	+	-	93.1
1979	8.1	22.0	17.3	8.0	10.4	6.8	1.1	.2	+	73.9
1980	3.6	17.4	19.4	9.5	4.4	2.5	2.8	.5	.3	60.6
1981	17.6	24.0	28.4	16.1	5.0	1.6	.8	.7	.4	94.7
1982	12.4	32.0	12.2	9.3	8.1	2.3	.9	.5	.5	78.0
1983	8.4	23.0	16.7	6.0	4.3	2.3	.9	.1	.2	61.8
1984	7.2	45.5	23.0	5.7	.9	.4	.3	.1	+	83.1
1985	7.6	26.1	23.1	7.6	1.5	.2	.2	+	+	66.5
1986	11.3	28.2	18.3	5.3	1.0	.2	.1	+	+	64.4

Table 14. Mean weight at age of silver hake from the Southern Georges Bank - Middle Atlantic stock.

Year	Age								
	1	2	3	4	5	6	7	8	9+
1955	.044	.101	.162	.222	.307	.422	.508	.662	.762
1956	.034	.074	.154	.223	.316	.438	.496	.664	.777
1957	.062	.085	.157	.224	.326	.465	.512	.683	.782
1958	.060	.088	.152	.215	.310	.409	.490	.682	-
1959	.035	.105	.156	.227	.333	.439	.485	.629	-
1960	.047	.074	.159	.216	.317	.445	.547	.702	.904
1961	.077	.105	.164	.217	.331	.498	.591	.832	.920
1962	.067	.106	.157	.215	.300	.441	.646	.778	1.007
1963	.076	.103	.161	.209	.286	.394	.468	.641	.906
1964	.057	.107	.154	.210	.301	.456	.545	.651	.929
1965	.063	.102	.153	.199	.300	.427	.512	.621	1.040
1966	.058	.089	.143	.207	.311	.453	.534	.654	.944
1967	.045	.092	.149	.204	.300	.451	.550	.701	.813
1968	.046	.096	.138	.194	.311	.454	.554	.767	.955
1969	.064	.111	.189	.243	.308	.399	.517	.698	1.135
1970	.049	.093	.163	.209	.270	.347	.445	.597	1.009
1971	.057	.096	.152	.204	.280	.343	.436	.580	.961
1972	.092	.201	.274	.370	.540	.451	.734	1.201	1.151
1973	.096	.167	.251	.399	.483	.539	.485	1.119	-
1974	.057	.178	.225	.302	.325	.415	.577	.680	.982
1975	.111	.141	.199	.332	.468	.585	.601	1.167	1.062
1976	.064	.168	.195	.228	.305	.606	.927	-	-
1977	.066	.168	.213	.257	.376	.573	.545	1.096	-
1978	.081	.192	.286	.344	.333	.530	1.106	.758	-
1979	.081	.183	.243	.287	.396	.358	.472	.638	1.625
1980	.103	.194	.212	.263	.265	.323	.278	.393	.731
1981	.060	.144	.159	.195	.265	.343	.357	.419	.428
1982	.106	.158	.210	.246	.208	.355	.435	.446	.673
1983	.113	.167	.207	.251	.285	.347	.299	.279	.522
1984	.044	.138	.183	.304	.324	.418	.242	.278	.720
1985	.089	.147	.214	.354	.520	.502	.367	.295	.269
1986	.078	.133	.193	.268	.352	.348	.301	.294	.270

Table 15. Fitted NEFC bottom trawl survey abundance indices for the Southern Georges Bank - Middle Atlantic stock (offshore strata 1-19, 61-76, inshore strata 1-46, 52, 55) of silver hake.

Year	Weight per tow (kg)		Number per tow	
	Spring	Autumn	Spring	Autumn
1963	-	3.86	-	36.74
1964	-	3.70	-	38.61
1965	-	3.55	-	45.46
1966	-	2.56	-	47.16
1967	-	2.11	-	33.85
1968	2.72	1.91	24.92	36.72
1969	2.12	1.44	21.00	32.93
1970	1.68	1.40	19.86	34.51
1971	1.84	1.60	19.86	40.36
1972	1.81	1.57	17.56	42.37
1973	2.36	1.39	19.83	41.91
1974	2.45	1.17	24.03	62.62
1975	2.88	1.45	23.39	65.46
1976	2.67	1.64	18.97	79.16
1977	2.58	1.71	14.02	82.37
1978	2.48	1.92	12.85	66.32
1979	1.96	1.68	11.19	49.45
1980	1.99	1.62	10.66	51.60
1981	1.97	1.42	10.30	52.88
1982	1.86	1.59	10.04	53.30
1983	1.73	1.95	10.99	47.77
1984	1.98	1.77	12.50	45.29
1985	2.16	2.07	14.83	52.31
1986	2.23	1.60	15.62	40.94

Table 16. Fitted mean number per tow at age for silver hake from the Southern Georges Bank - Middle Atlantic stock (offshore strata 1-19,61-76, inshore strata 1-46, 52, 55) from NEFC bottom trawl surveys in the spring and autumn.

Year	Age										Total		
	0	1	2	3	4	5	6	7	8	9+	0+	1+	2+
Spring													
1973	-	6.50	8.01	3.83	1.23	.13	.07	.05	-	.01	19.83	19.83	13.33
1974	-	18.33	1.41	2.29	1.33	.45	.15	.05	-	.01	24.03	24.03	5.69
1975	-	12.06	3.17	6.00	1.65	.46	.04	.01	-	-	23.39	23.39	11.32
1976	-	10.04	4.28	2.83	1.42	.31	.09	.01	-	-	18.97	18.97	8.93
1977	-	2.19	1.90	5.67	3.14	.65	.26	.18	.02	-	14.02	14.02	11.83
1978	-	5.63	2.56	1.38	2.01	.95	.28	.03	.01	-	12.85	12.85	7.22
1979	-	6.21	1.73	1.19	.56	.86	.57	.06	-	-	11.19	11.19	4.98
1980	-	3.70	3.16	2.16	.81	.26	.27	.22	.07	.02	10.66	10.66	6.97
1981	-	3.75	1.88	2.04	1.39	.65	.25	.14	.10	.10	10.30	10.30	6.55
1982	-	1.65	3.93	1.29	1.30	1.08	.38	.23	.07	.12	10.04	10.04	8.39
1983	-	4.44	4.14	1.17	.63	.26	.20	.11	.01	.02	10.99	10.99	6.55
1984	-	2.68	6.24	2.60	.65	.14	.12	.05	.02	.01	12.50	12.50	9.82
1985	-	7.02	3.14	3.14	1.12	.28	.06	.05	.02	.01	14.83	14.83	7.81
1986	-	3.44	7.87	3.17	.88	.16	.04	.04	.02	.01	15.62	15.62	12.18
Autumn													
1973	23.98	6.59	7.04	3.00	.85	.43	.02	-	-	-	41.91	17.93	11.34
1974	59.51	2.05	.77	.22	.05	.02	-	-	-	-	62.62	3.11	1.06
1975	54.62	5.06	2.90	1.76	.72	.24	.10	.03	.01	.01	65.46	10.84	5.78
1976	70.68	1.84	3.64	1.94	.67	.18	.10	.09	.01	-	79.16	8.47	6.63
1977	76.86	2.18	.86	1.69	.57	.13	.02	.04	.03	-	82.37	5.52	3.34
1978	48.93	8.12	3.61	2.36	2.15	.97	.14	.05	-	-	66.32	17.39	9.27
1979	36.66	3.94	3.43	2.49	1.21	.87	.70	.13	.02	-	49.45	12.79	8.86
1980	41.34	3.60	1.34	3.22	1.00	.48	.19	.37	.03	.02	51.60	10.26	6.65
1981	47.59	2.34	.75	1.13	.81	.18	.04	-	.05	-	52.88	5.29	2.95
1982	48.00	2.25	1.80	.72	.31	.14	.05	-	.02	.01	53.30	5.30	3.05
1983	30.75	9.71	4.37	2.17	.42	.20	.07	.06	-	-	47.77	17.02	7.30
1984	33.00	7.11	3.40	1.37	.36	.05	-	-	-	-	45.29	12.29	5.18
1985	41.30	7.49	1.62	1.44	.41	.03	.02	-	-	-	52.31	11.00	3.52
1986	24.40	10.56	3.23	2.14	.47	.14	-	-	-	-	40.94	16.54	5.98

Table 17. Estimation of F in 1986 for the Southern Georges Bank - Middle Atlantic silver hake fishery.

Year	Fitted autumn survey catch/tow (age 2+ numbers)	Total catch	Relative exploitation index ¹	Fishing mortality ²
1973	11.34	104,593	9,223	.572
1974 ⁵	1.06	109,863	103,644	.556
1975	5.78	74,253	12,847	.414
1976	6.63	68,741	10,368	.530
1977	3.34	59,308	17,757	.758
1978	9.27	27,132	2,927	.431
1979	8.86	18,375	2,074	.326
1980	6.65	13,546	2,037	.305
1981	2.95	14,826	5,026	.594
1982	3.05	14,561	4,774	(.445) ^{3,4}
1983	7.30	12,140	1,663	(.329) ^{3,4}
1984	5.18	13,143	2,537	(.371) ^{3,4}
1985	3.52	13,164	3,740	(.415) ^{3,4}
1986	5.98	10,123	1,693	(.330) ³

¹Total international catch divided by survey catch per tow index.

²Weighted mean F for fully-recruited ages.

³Calculated from power curve relationship of relative exploitation on fishing mortality for 1973-1981:

.2854

$$Y = .0396X \quad r = .779$$

⁴Values calculated from VPA were .629, .536, .566, and .386.

⁵Not used in calculation of relationship because F value appeared to be excessively low for amount of relative exploitation in comparison to other years.

Table 19. Stock size estimates (millions) for the Southern Georges Bank - Middle Atlantic silver hake stock derived from virtual population analysis (M = .40).

AGE	1955	1956	1957	1958	1959	1960	1961	1962	1963	1964	1965	1966
STOCK SIZE												
1	470.8	416.4	534.7	496.3	1015.6	1733.9	2206.2	3568.8	4289.8	3115.4	2083.2	1319.1
2	188.2	301.5	229.1	356.7	316.0	671.4	1153.7	1546.7	2500.1	2872.8	2076.0	1358.8
3	122.5	118.4	164.4	135.6	216.6	202.5	436.4	769.1	1033.1	1648.9	1872.8	1226.6
4	49.7	66.0	62.9	85.0	70.9	115.6	125.5	271.3	489.9	553.9	873.8	541.8
5	18.9	16.1	32.0	24.1	44.5	27.8	68.9	66.7	153.9	172.2	156.6	154.7
6	6.1	5.8	6.4	13.7	11.8	22.8	14.7	41.7	36.6	60.4	48.1	45.5
7	2.3	2.6	2.8	2.3	8.1	6.3	14.0	8.6	26.4	17.9	24.9	19.4
8	1.1	1.0	1.2	1.1	.9	4.8	3.5	8.6	4.6	15.6	4.5	10.8
9+	.4	.5	.4	-	-	1.2	2.3	4.3	1.9	6.5	1.5	2.6
TOT NOS	859.9	928.1	1033.9	1114.8	1684.4	2786.4	4025.2	6285.9	8536.3	8463.6	7141.5	4679.4
SPWN NOS	305.8	382.1	397.1	465.5	528.4	767.1	1324.1	2044.5	3169.8	4087.9	4113.5	2741.9
AGE	1967	1968	1969	1970	1971	1972	1973	1974	1975	1976	1977	1978
1	848.4	487.1	506.6	671.5	1090.3	1421.5	1391.2	1129.3	734.0	212.2	200.5	233.8
2	869.1	555.7	318.7	338.5	416.2	725.1	844.4	873.5	697.2	487.8	136.1	132.3
3	621.9	484.4	352.7	197.4	206.5	245.6	346.0	307.0	406.1	381.3	257.1	63.9
4	418.4	244.0	209.7	147.5	118.3	65.2	75.9	141.6	93.8	153.1	141.7	67.7
5	135.0	156.9	91.1	61.0	72.6	18.0	17.6	27.5	36.5	22.8	28.3	40.5
6	42.2	65.7	81.8	28.8	22.5	14.0	8.0	7.9	5.0	8.9	7.0	10.1
7	10.8	22.4	35.1	45.6	14.1	1.0	7.7	4.5	.7	1.2	4.9	2.2
8	4.4	4.8	11.5	15.3	26.5	.3	.3	4.7	.4	-	.7	-
9+	.9	2.8	7.1	7.1	19.1	.3	-	1.4	3.5	-	-	-
TOT NOS	2951.3	2023.8	1614.2	1512.6	1986.1	2491.0	2691.1	2497.4	1977.3	1267.2	776.3	550.5
SPWN NOS	1715.4	1284.7	959.4	692.5	714.9	759.9	936.4	994.6	937.1	835.9	507.1	259.3
AGE	1979	1980	1981	1982	1983	1984	1985	1986	1987			
1	189.4	114.5	159.5	167.6	227.6	229.5	188.8	(200) ¹	(200) ²			
2	154.9	120.4	73.8	92.7	102.3	145.7	148.0	120.4	124.9			
3	67.2	86.1	66.6	30.3	36.5	50.1	61.2	78.1	58.0			
4	26.5	31.1	42.1	22.1	10.6	11.3	15.3	22.6	37.7			
5	23.1	11.4	13.3	15.4	7.4	2.4	3.0	4.3	10.9			
6	17.2	7.2	4.1	4.9	3.9	1.6	.9	.9	2.1			
7	4.7	6.1	2.9	1.5	1.5	.8	.7	.4	.4			
8	.9	2.3	1.9	1.3	.3	.3	-	-	.2			
9+	-	1.4	1.1	1.3	.6	-	-	-	-			
TOT NOS	483.9	380.4	365.1	336.9	390.6	441.6	418.1	426.7	434.1			
SPWN NOS	227.6	212.3	172.1	129.8	119.3	149.9	165.5	173.5	180.0			

¹Estimated (see Table 21).²Mean 1981-1985 year-class size.

Table 20. Stock biomass estimates (000's mt) for the Southern Georges Bank - Middle Atlantic silver hake stock derived from virtual population analysis (M = .40).

AGE	1955	1956	1957	1958	1959	1960	1961	1962	1963	1964	1965	1966
STOCK BIOMASS AT AGE												
1	20.7	14.2	33.2	29.8	35.5	81.5	169.9	239.1	326.0	177.6	131.2	76.5
2	19.0	22.3	19.5	31.4	33.2	49.7	121.1	163.9	257.5	307.4	211.8	120.9
3	19.8	18.2	25.8	20.6	33.8	32.2	71.6	120.8	166.3	253.9	286.5	175.4
4	11.0	14.7	14.1	18.3	16.1	25.0	27.2	58.3	102.4	116.3	173.9	112.2
5	5.8	5.1	10.4	7.5	14.8	8.8	22.8	20.0	44.0	51.8	47.0	48.1
6	2.6	2.5	3.0	5.6	5.2	10.1	7.3	18.4	14.4	27.5	20.6	20.6
7	1.2	1.3	1.4	1.1	3.9	3.5	8.3	5.6	12.3	9.8	12.7	10.4
8	.7	.6	.8	.7	.6	3.4	2.9	6.7	3.0	10.2	2.8	7.1
9+	.3	.4	.3	-	-	1.1	2.1	5.3	1.8	6.0	1.6	2.5
TOT WGT	81.1	79.3	108.5	115.0	143.1	215.3	433.3	638.1	927.8	960.5	888.1	573.6
SPWN WGT	51.6	55.1	66.1	71.3	92.3	111.8	210.1	325.7	487.8	644.2	655.7	438.8
AGE	1967	1968	1969	1970	1971	1972	1973	1974	1975	1976	1977	1978
1	38.2	22.4	32.4	32.9	62.1	130.8	133.6	64.4	81.5	13.6	13.2	18.9
2	80.0	53.4	35.4	31.5	40.0	145.7	141.0	155.5	98.3	81.9	22.9	25.4
3	92.7	66.8	66.7	32.2	31.4	67.3	86.8	69.1	80.8	74.3	54.8	18.3
4	85.4	47.3	51.0	30.8	24.1	24.1	30.3	42.8	31.2	34.9	36.4	23.3
5	40.5	48.8	28.1	16.5	20.3	9.7	8.5	8.9	17.1	6.9	10.6	13.5
6	19.1	29.8	32.6	10.0	7.7	6.3	4.3	3.3	2.9	5.4	4.0	5.3
7	5.9	12.4	18.1	20.3	6.1	.7	3.7	2.6	.4	1.1	2.7	2.5
8	3.1	3.7	8.0	9.1	15.4	.4	.3	3.2	.4	-	.7	-
9+	.7	2.7	8.1	7.2	18.4	.4	-	1.4	3.7	-	-	-
TOT WGT	365.5	287.4	280.3	190.4	225.6	385.4	408.6	351.1	316.3	218.2	145.3	107.2
SPWN WGT	289.9	239.8	230.1	143.0	145.5	191.5	212.9	219.5	190.5	167.3	120.0	76.9
AGE	1979	1980	1981	1982	1983	1984	1985	1986	1987			
1	15.3	11.8	9.6	17.8	25.7	10.1	16.8	15.6	15.6			
2	28.4	23.4	10.6	14.6	17.1	20.1	21.8	16.0	16.6			
3	16.3	18.2	10.6	6.4	7.6	9.2	13.1	15.1	11.2			
4	7.6	8.2	8.2	5.4	2.7	3.4	5.4	6.1	10.1			
5	9.2	3.0	3.5	3.2	2.1	.8	1.6	1.5	3.8			
6	6.1	2.3	1.4	1.7	1.4	.7	.4	.3	.7			
7	2.2	1.7	1.0	.6	.4	.2	.3	.1	.1			
8	.6	.9	.8	.6	.1	.1	-	-	.1			
9+	-	1.0	.5	.9	.3	-	-	-	-			
TOT WGT	85.7	70.5	46.2	51.2	57.3	44.5	59.4	54.7	58.2			
SPWN WGT	57.9	48.2	31.7	27.1	24.2	25.7	33.0	31.8	35.3			

Table 21. Relationship between fitted survey catch per tow at age 1 (numbers) and year-class size at age 1 (millions) from VPA for the Southern Georges Bank - Middle Atlantic silver hake stock.

Year class	Spring survey Age 1	Stock size Age 1
1973	18.33	1129.3
1974	12.06	734.0
1975	10.04	212.2
1976	2.19	200.5
1977	5.63	233.8
1978	6.21	189.4
1979	3.70	114.5
1980	3.75	159.5
1981	1.68	167.6
1982	4.44	227.6
1983	2.68	229.5
1984 ²	7.02	188.8
1985	3.44	(194.3) ¹

¹Calculated from a power curve relationship of spring survey number per tow on VPA year-class size for 1973-1984:

$$Y = 82.7151X^{.6912}, \quad r = .755$$

²Not used in relationship.

Table 22. Projected catch (age 1+) in 1987 from the Southern Georges Bank - Middle Atlantic stock of silver hake with fishing mortality (F) ranging from .05 to .60, and assuming 200 million recruits in 1987. Resulting stock size (age 2+) in 1988 and the percentage change (by weight) from 1988 are also given.

F	1987 Catch	1988 Stock	% change in stock from 1987
0.05	1.9	54.3	27.2
0.10	3.6	52.3	22.5
0.15	5.3	50.4	18.0
0.20	7.0	48.6	13.8
0.25	8.5	46.9	9.8
0.30	10.0	45.2	5.9
0.35 ¹	11.5	43.7	2.3
0.40	12.8	42.1	-1.4
0.45	14.1	40.7	-4.7
0.50	15.4	39.3	-8.0
0.55	16.6	38.0	-11.0
0.60	17.8	36.8	-13.8

¹F_{0.1}

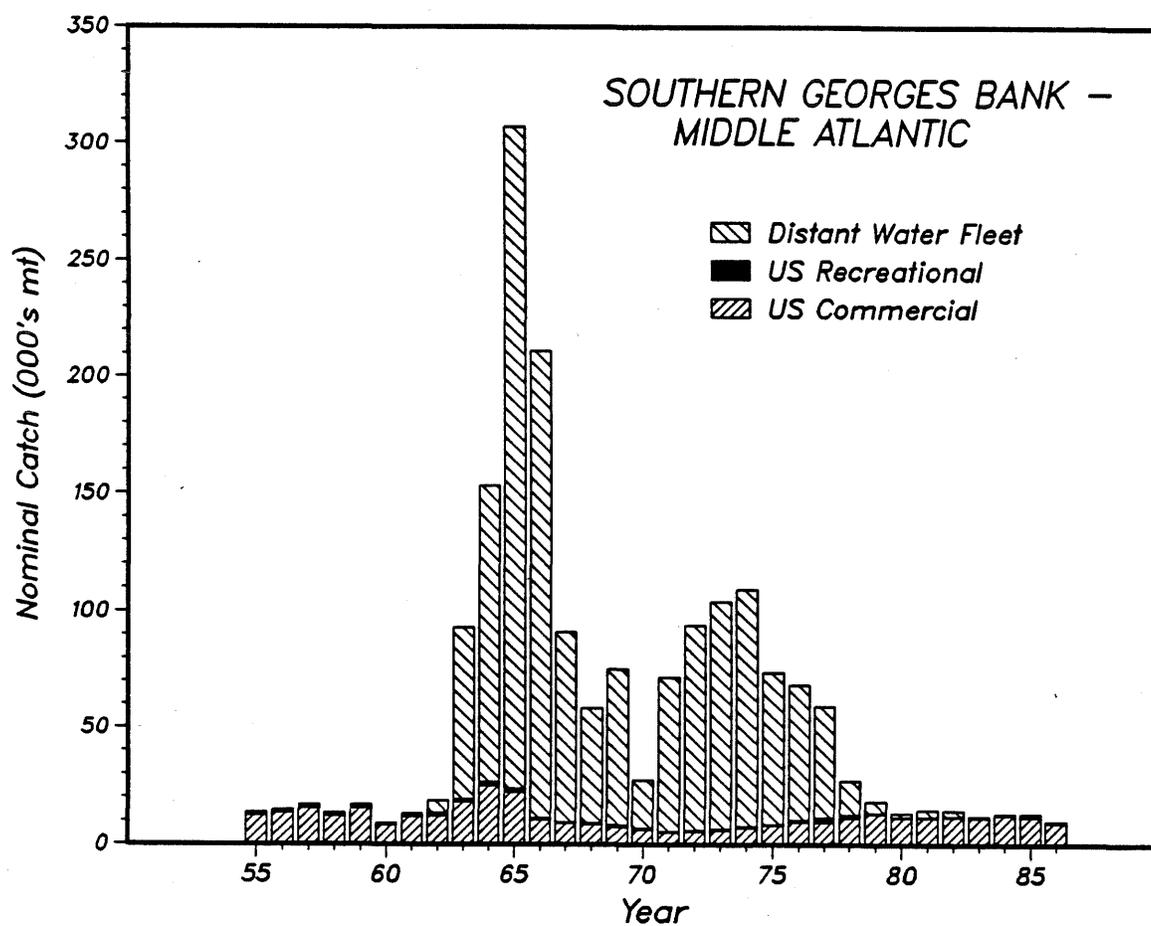


Figure 7. US commercial and distant-water-fleet components of the total catch from the Southern Georges Bank - Middle Atlantic silver hake stock.

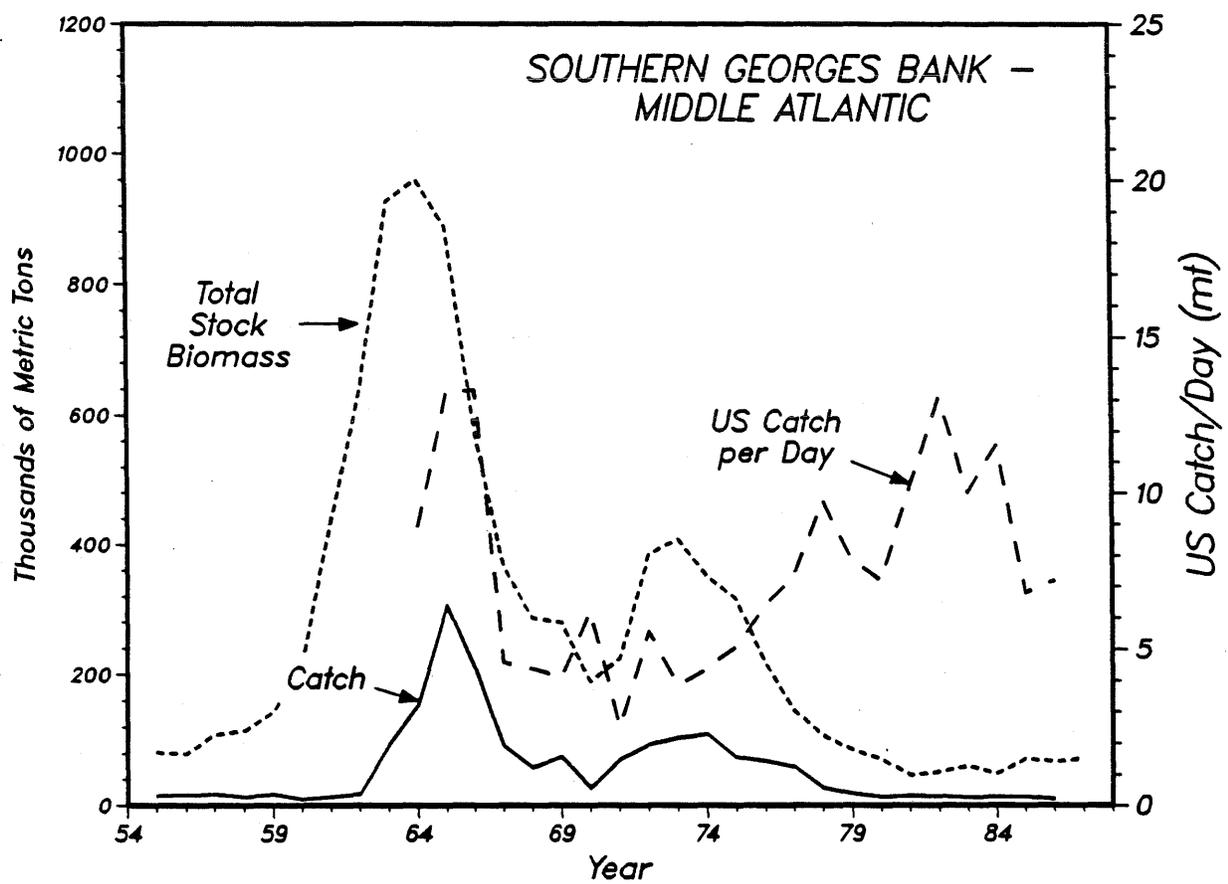


Figure 8. International catch, stock biomass (age 1+) from VPA, and commercial catch/day from the Southern Georges Bank - Middle Atlantic silver hake stock.

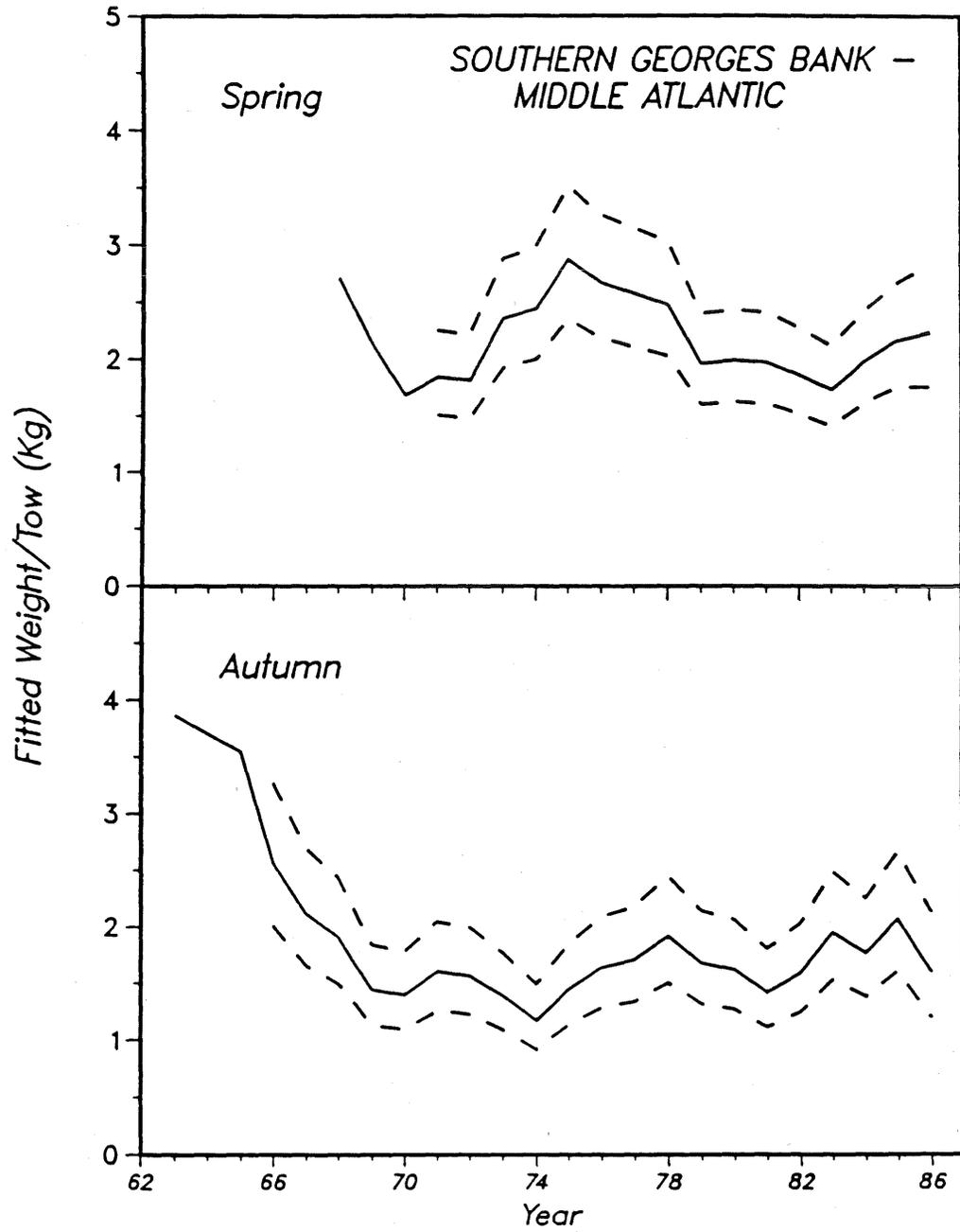


Figure 9. Fitted weight-per-tow indices from spring and autumn NEFC bottom trawl surveys during 1963-1986 with 80% confidence intervals.

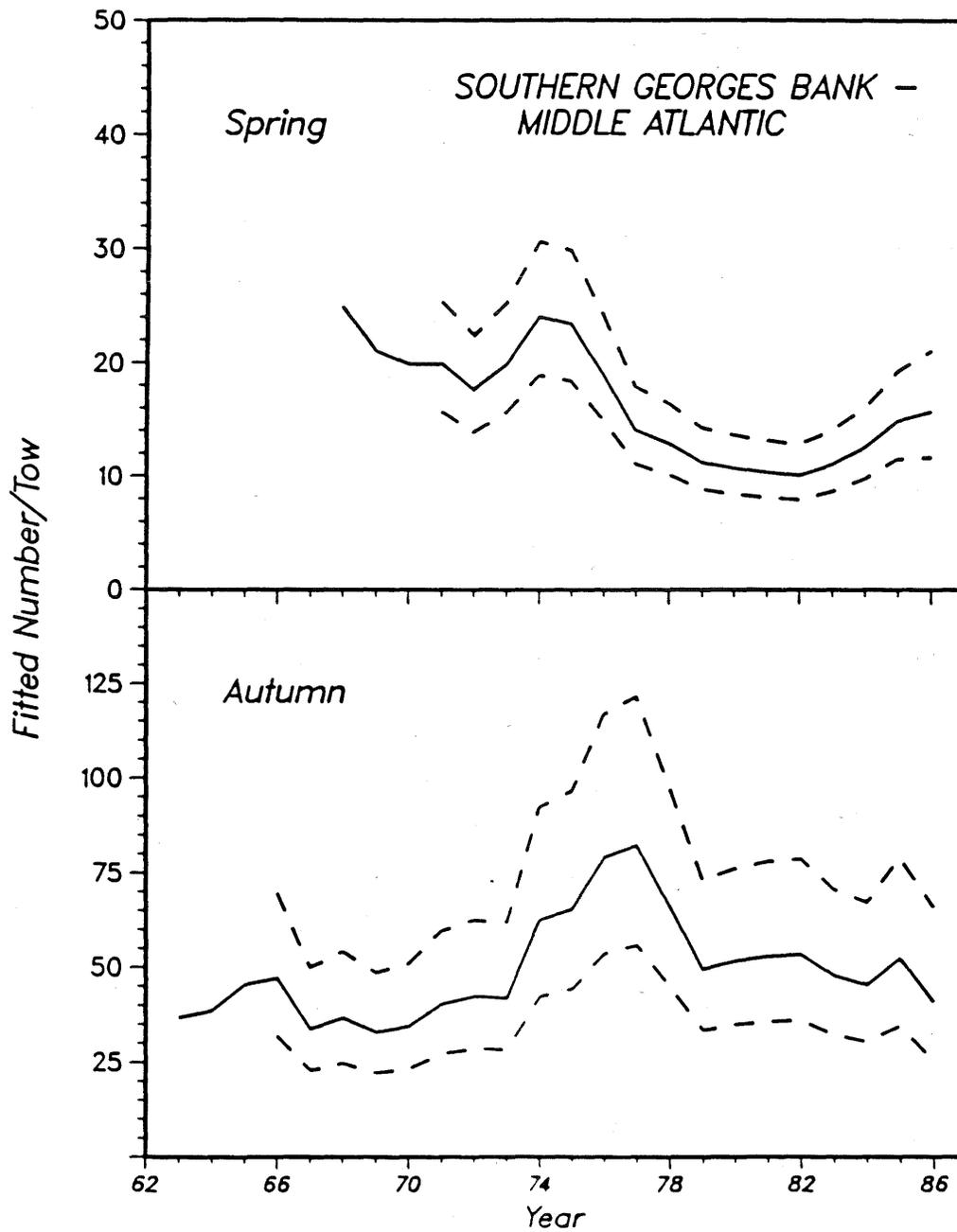


Figure 10. Fitted number-per-tow indices from spring and autumn NEFC bottom trawl surveys during 1963-1986 with 80% confidence intervals.

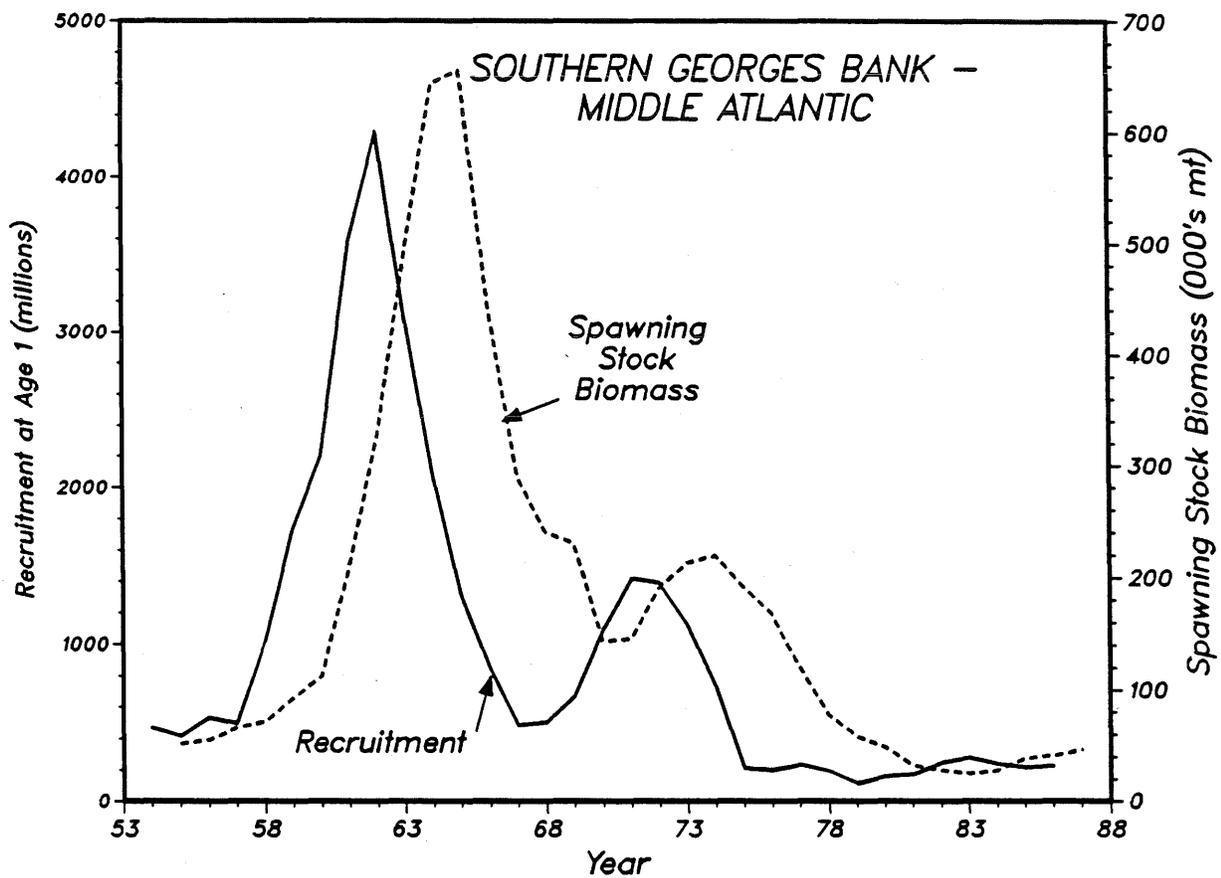


Figure 11. Spawning stock biomass during 1955-1987 and abundance at age 1 of the 1954-1986 year classes from VPA.

Appendix Table 1. Stratified mean weight per tow (linear) of silver hake from the Gulf of Maine - Northern Georges Bank stock (strata 20-30, 36-40) from NEFC bottom trawl surveys.

Year	Mean	Variance	Standard Deviation	Coefficient of Variation
Spring				
1968	.04	<.001	.017	47.8
1969	.19	.003	.053	27.8
1970	14.13	178.280	13.352	94.5
1971	.41	.016	.125	30.8
1972	1.70	.422	.649	38.2
1973 ¹	2.01	.398	.631	31.4
1974 ¹	1.73	.105	.325	18.8
1975 ¹	6.26	3.179	1.783	28.5
1976 ¹	5.69	1.202	1.096	19.3
1977 ¹	2.38	.163	.403	16.9
1978 ¹	.52	.009	.093	17.8
1979 ¹	1.04	.041	.202	19.4
1980 ¹	2.67	.169	.411	15.4
1981 ¹	1.49	.060	.244	16.4
1982	1.35	.074	.272	20.2
1983	1.51	.110	.332	22.0
1984	1.09	.030	.174	16.0
1985	2.64	.551	.742	28.1
1986	3.25	.643	.802	24.7
Autumn				
1963	25.42	38.434	6.200	24.4
1964	4.44	.771	.878	19.8
1965	6.50	3.175	1.782	27.4
1966	4.12	.585	.765	18.5
1967	2.16	.332	.576	26.7
1968	2.05	.298	.546	26.7
1969	2.63	.339	.583	22.1
1970	3.03	.637	.798	26.3
1971	2.47	.248	.498	20.2
1972	6.09	.897	.947	15.6
1973	4.15	.330	.575	13.8
1974	3.76	1.070	1.034	27.5
1975	8.23	1.270	1.127	13.7
1976	12.63	7.629	2.762	21.9
1977	7.59	6.122	2.474	32.6
1978	7.07	.940	.970	13.7
1979	6.65	.948	.974	14.6
1980	6.66	1.452	1.205	18.1
1981	4.06	1.049	1.025	25.3
1982	5.45	9.380	3.063	56.2
1983	9.20	3.549	1.884	20.5
1984	3.62	.613	.783	21.6
1985	8.58	1.977	1.406	16.4
1986	14.19	5.401	2.324	16.4

¹Adjusted from #41 trawl catches to equivalent #36 trawl catches using a .400:1 ratio.

Appendix Table 2. Stratified mean number per tow (linear) of silver hake from the Gulf of Maine - Northern Georges Bank stock (strata 20-30, 36-40) from NEFC bottom trawl surveys.

Year	Mean	Variance	Standard Deviation	Coefficient of Variation
Spring				
1968	52	.018	.134	25.7
1969	6.37	1.056	1.027	16.1
1970	38.70	938.870	30.641	79.2
1971	5.71	1.702	1.305	22.8
1972	43.31	113.630	10.660	24.6
1973 ¹	16.34	14.551	3.815	23.3
1974 ¹	40.57	100.740	10.037	24.7
1975 ¹	123.00	1053.900	32.463	26.4
1976 ¹	49.23	83.968	9.163	18.6
1977 ¹	16.46	7.003	2.646	16.1
1978 ¹	5.63	1.158	1.076	19.1
1979 ¹	18.46	10.406	3.226	17.5
1980 ¹	26.77	18.646	4.318	16.1
1981 ¹	20.71	16.385	4.048	19.5
1982	20.18	10.841	3.293	16.3
1983	20.85	12.263	3.502	16.8
1984	10.36	3.026	1.739	16.8
1985	47.29	408.010	20.199	42.7
1986	95.42	586.160	24.211	25.4
Autumn				
1963	232.92	4265.000	65.307	28.0
1964	25.19	22.264	4.718	18.7
1965	32.26	94.591	9.726	30.2
1966	17.79	10.816	3.289	18.5
1967	9.42	7.267	2.696	28.6
1968	7.50	2.437	1.561	20.8
1969	15.29	9.080	3.013	19.7
1970	16.74	24.060	4.905	29.3
1971	30.41	72.504	8.515	28.0
1972	51.59	63.623	7.976	15.5
1973	25.80	16.893	4.110	15.9
1974	27.20	26.768	5.174	19.0
1975	79.38	266.330	16.320	20.6
1976	56.34	71.788	8.473	15.0
1977	34.61	129.930	11.399	32.9
1978	46.00	78.405	8.855	19.2
1979	52.96	80.097	8.950	16.9
1980	39.61	41.242	6.422	16.2
1981	23.99	20.028	4.475	18.7
1982	41.54	141.030	11.876	28.6
1983	77.09	357.980	18.920	24.5
1984	24.84	21.903	4.680	18.8
1985	92.70	214.310	14.639	15.8
1986	122.94	282.840	16.818	13.7

¹Adjusted from #41 trawl catches to equivalent #36 trawl catches using a .334:1 ratio.

Appendix Table 3. Stratified mean number per tow (Delta) at age for silver hake from the Gulf of Maine - Northern Georges Bank stock (strata 20-30, 36-40) from NEFC bottom trawl surveys in the spring and autumn.

Year	Age										Total		
	0	1	2	3	4	5	6	7	8	9+	0+	1+	2+
Spring													
1973 ¹	-	4.64	10.46	1.05	.13	.05	.01	-	-	-	16.34	16.34	11.70
1974 ¹	-	34.59	3.62	1.73	.39	.11	.05	.05	.01	.02	40.57	40.57	5.98
1975 ¹	-	56.51	57.52	7.29	1.23	.40	.05	-	-	-	123.00	123.00	66.49
1976 ¹	-	10.53	23.58	12.78	1.48	.51	.28	.04	.02	-	49.23	49.23	38.70
1977 ¹	-	5.00	4.88	4.25	1.71	.34	.13	.13	.02	.01	16.46	16.46	11.46
1978 ¹	-	3.57	1.55	.29	.16	.04	.01	.01	-	-	5.63	5.63	2.06
1979 ¹	-	7.06	10.80	.37	.07	.05	.04	.05	.03	-	18.46	18.46	11.40
1980 ¹	-	3.67	16.65	5.71	.40	.11	.10	.08	.02	.04	26.77	26.77	23.10
1981 ¹	-	9.92	5.70	3.69	1.17	.17	.06	-	.01	-	20.71	20.71	10.79
1982	-	11.32	5.77	1.64	.77	.54	.09	.01	-	.04	20.18	20.18	8.86
1983	-	10.85	8.40	.89	.28	.30	.11	.02	-	-	20.85	20.85	10.00
1984	-	3.80	5.28	.98	.11	.08	.08	.03	-	-	10.36	10.36	6.56
1985	-	39.49	4.13	2.36	.92	.20	.07	.11	-	-	47.29	47.29	7.80
1986 ²	-	87.10	5.81	1.74	.57	.14	.06	-	-	-	95.42	95.42	8.32
Autumn													
1973	5.87	7.20	8.51	3.24	.48	.32	.12	-	-	.06	25.80	19.93	12.73
1974	18.30	3.56	2.97	1.80	.25	.22	.11	-	-	-	27.20	8.90	5.34
1975	18.36	17.41	32.09	7.61	2.39	.87	.26	.08	.30	-	79.38	61.02	43.61
1976	6.48	3.26	14.61	20.36	8.60	1.40	1.08	.51	.01	.03	56.34	49.86	46.60
1977	2.66	3.03	6.05	13.05	8.21	1.34	.23	.05	-	-	34.61	31.95	28.93
1978	19.65	5.22	4.77	3.39	4.92	6.46	1.27	.12	.21	-	46.00	26.35	21.13
1979	1.16	28.44	17.35	2.06	.96	1.19	1.51	.25	.02	.02	52.96	51.80	23.36
1980	5.47	3.56	12.11	11.89	2.73	1.02	.83	1.52	.42	.08	39.61	34.14	30.58
1981	1.33	7.66	4.07	5.19	3.95	.75	.29	.28	.40	.07	23.99	22.66	14.99
1982	9.59	14.46	8.63	3.18	2.67	2.57	.24	.07	.07	.07	41.54	31.95	17.49
1983	1.45	43.04	29.76	1.22	.59	.63	.30	.06	.02	.01	77.09	75.64	32.60
1984	8.42	6.02	7.38	2.23	.50	.18	.10	-	-	.01	24.84	16.42	10.40
1985	37.59	43.00	3.97	6.61	1.41	.09	.01	.02	-	-	92.70	55.11	12.11
1986 ²	14.52	87.78	6.34	11.58	2.45	.20	.04	.03	-	-	122.94	108.42	20.64

¹Adjusted from #41 trawl catches to equivalent #36 trawl catches using a .334:1 ratio.

²Preliminary estimates utilizing 1985 age data.

Appendix Table 4. Stratified mean weight per tow (linear) of silver hake from the Southern Georges Bank - Middle Atlantic stock (offshore strata 1-19, 61-76, inshore strata 1-46, 52, 55) from NEFC bottom trawl surveys.

Year	Mean	Variance	Standard Deviation	Coefficient of Variation
Spring				
1968 ¹	3.57	2.355	1.535	43.0
1969 ¹	2.09	.167	.409	19.5
1970 ¹	1.17	.028	.167	14.3
1971 ¹	2.08	.082	.286	13.8
1972 ¹	1.33	.039	.199	14.9
1973 ²	3.04	.188	.434	14.3
1974 ²	2.13	.114	.338	15.9
1975 ²	3.76	.552	.743	19.8
1976 ³	2.56	.164	.405	15.8
1977 ³	2.59	.155	.393	15.2
1978 ³	3.08	.271	.520	16.9
1979 ³	1.49	.097	.311	20.9
1980 ³	2.04	.102	.320	15.7
1981 ³	2.09	.093	.304	14.6
1982	1.88	.176	.420	22.3
1983	1.38	.045	.211	15.3
1984	2.09	.222	.472	22.6
1985	2.30	.159	.399	17.4
1986	2.31	.163	.404	17.5
Autumn				
1963 ^{4,5}	4.05	.996	.998	24.6
1964 ^{4,5}	3.71	.449	.670	18.1
1965 ^{4,5}	4.84	.690	.831	17.2
1966 ^{4,5}	2.22	.120	.346	15.6
1967 ⁴	1.90	.069	.263	13.8
1968 ⁴	2.34	.088	.296	12.7
1969 ⁴	1.09	.022	.149	13.6
1970 ⁴	1.16	.023	.151	13.1
1971 ⁴	1.92	.099	.315	16.4
1972 ⁴	1.74	.144	.380	21.9
1973 ⁴	1.48	.067	.258	17.5
1974	.76	.024	.156	20.5
1975	1.59	.067	.259	16.2
1976	1.80	.058	.242	13.5
1977	1.58	.137	.370	23.4
1978	2.53	.359	.599	23.7
1979	1.51	.030	.174	11.6
1980	1.80	.388	.623	34.5
1981	1.07	.071	.267	24.9
1982	1.44	.079	.282	19.5
1983	2.73	.919	.959	35.1
1984	1.32	.159	.398	30.1
1985	3.29	2.603	1.613	49.1
1986	1.20	.042	.204	17.0

¹Adjusted from offshore #36 trawl catches to equivalent inshore-offshore #36 trawl catches using a .950:1 ratio.

²Adjusted from offshore #41 trawl catches to equivalent inshore-offshore #36 trawl catches using a .380:1 ratio.

³Adjusted from inshore-offshore #41 trawl catches to equivalent inshore-offshore #36 trawl catches using a .400:1 ratio.

⁴Adjusted from offshore #36 trawl catches to equivalent inshore-offshore #36 trawl catches using a .869:1 ratio.

⁵Strata 1-19 only.

Appendix Table 5. Stratified mean number per tow (linear) of silver hake from the Southern Georges Bank - Middle Atlantic stock (offshore strata 1-19, 61-76, inshore strata 1-46, 52, 55) from NEFC bottom trawl surveys.

Year	Mean	Variance	Standard Deviation	Coefficient of Variation
Spring				
1968 ¹	35.10	172.380	13.129	37.4
1969 ¹	16.68	13.493	3.673	22.0
1970 ¹	17.75	10.491	3.239	18.3
1971 ¹	25.44	30.435	5.517	21.7
1972 ¹	10.75	2.987	1.728	16.1
1973 ²	17.23	4.486	2.118	12.3
1974 ²	37.22	178.010	13.342	35.8
1975 ²	33.70	50.101	7.078	21.0
1976 ³	22.82	30.163	5.492	24.1
1977 ³	9.12	1.579	1.257	13.8
1978 ³	14.24	3.893	1.973	13.9
1979 ³	9.33	4.508	2.123	22.8
1980 ³	10.38	3.446	1.856	17.9
1981 ³	10.12	1.379	1.174	11.6
1982	7.96	1.427	1.195	15.0
1983	10.18	2.158	1.469	14.4
1984	11.50	3.279	1.811	15.7
1985	18.82	11.939	3.455	18.4
1986	17.33	9.119	3.020	17.4
Autumn				
1963 ^{4,5}	33.26	65.507	8.094	24.3
1964 ^{4,5}	30.75	53.247	7.297	23.7
1965 ^{4,5}	58.56	110.860	10.529	18.0
1966 ^{4,5}	98.52	879.590	29.658	30.1
1967 ⁴	14.81	2.653	1.629	11.0
1968 ⁴	53.74	228.690	15.123	28.1
1969 ⁴	24.12	34.347	5.861	24.3
1970 ⁴	27.72	59.997	7.746	27.9
1971 ⁴	50.07	166.040	12.886	25.7
1972 ⁴	47.74	290.670	17.049	35.7
1973 ⁴	18.37	18.469	4.298	23.4
1974	127.95	1518.000	38.961	30.4
1975	48.91	262.820	16.212	33.1
1976	106.90	3837.400	61.947	57.9
1977	137.60	4435.700	66.601	48.4
1978	77.32	1535.700	39.188	50.7
1979	25.25	23.635	4.862	19.3
1980	53.48	651.290	25.520	47.7
1981	54.65	979.867	31.303	57.3
1982	67.45	413.540	20.336	30.2
1983	42.68	514.610	22.685	53.1
1984	30.51	94.673	9.730	31.9
1985	113.90	1330.700	36.479	32.0
1986	25.08	35.156	5.929	23.6

¹Adjusted from offshore #36 trawl catches to equivalent inshore-offshore #36 trawl catches using a .960:1 ratio.

²Adjusted from offshore #41 trawl catches to equivalent inshore-offshore #36 trawl catches using a .320:1 ratio.

³Adjusted from inshore-offshore #41 trawl catches to equivalent inshore-offshore #36 trawl catches using a .334:1 ratio.

⁴Adjusted from offshore #36 trawl catches to equivalent inshore-offshore #36 trawl catches using a .890:1 ratio.

⁵Strata 1-19 only.

Appendix Table 6. Stratified mean number per tow (linear) at age for silver hake from the Southern Georges Bank - Middle Atlantic stock (offshore strata 1-19,61-76, inshore strata 1-46, 52, 55) from NEFC bottom trawl surveys in the spring and autumn.

Year	Age										Total		
	0	1	2	3	4	5	6	7	8	9+	0+	1+	2+
Spring													
1973 ¹	-	5.65	6.96	3.33	1.07	.11	.06	.04	-	.01	17.23	17.23	11.58
1974 ¹	-	28.40	2.19	3.55	2.06	.69	.24	.07	-	.01	37.22	37.22	8.82
1975 ¹	-	17.38	4.57	8.64	2.38	.66	.06	.01	-	-	33.70	33.70	16.32
1976 ²	-	12.08	5.15	3.40	1.70	.37	.10	.02	-	-	22.82	22.82	10.74
1977 ²	-	1.42	1.24	3.69	2.05	.42	.17	.12	.02	-	9.12	9.12	7.70
1978 ²	-	6.24	2.84	1.53	2.22	1.05	.32	.03	.01	-	14.24	14.24	8.00
1979 ²	-	5.18	1.44	1.00	.47	.72	.48	.05	-	-	9.33	9.33	4.15
1980 ²	-	3.60	3.07	2.10	.79	.25	.27	.21	.07	.02	10.38	10.38	6.78
1981 ²	-	3.69	1.84	2.01	1.37	.64	.25	.14	.09	.09	10.12	10.12	6.43
1982	-	1.31	3.11	1.02	1.03	.86	.30	.18	.06	.10	7.96	7.96	6.65
1983	-	4.12	3.83	1.08	.58	.24	.19	.11	.01	.02	10.18	10.18	6.06
1984	-	2.47	5.74	2.39	.59	.13	.11	.05	.02	.01	11.50	11.50	9.03
1985	-	8.91	3.98	3.99	1.41	.35	.08	.07	.03	.01	18.82	18.82	9.91
1986 ⁴	-	3.82	8.73	3.52	.97	.18	.04	.04	.02	.01	17.33	17.33	13.51
Autum													
1973 ³	10.51	2.89	3.09	1.32	.37	.19	.01	-	-	-	18.37	7.86	4.97
1974	121.59	4.19	1.58	.45	.10	.04	-	-	-	-	127.95	6.36	2.17
1975	40.81	3.78	2.16	1.32	.54	.18	.07	.02	.01	.01	48.91	8.10	4.32
1976	95.46	2.49	4.92	2.62	.91	.24	.13	.12	.01	-	106.91	11.45	8.96
1977	128.39	3.63	1.44	2.82	.96	.21	.03	.06	.05	-	137.60	9.21	5.58
1978	57.05	9.46	4.20	2.76	2.50	1.13	.16	.05	-	-	77.32	20.27	10.81
1979	18.72	2.01	1.75	1.27	.62	.45	.36	.07	.01	-	25.25	6.53	4.52
1980	42.85	3.74	1.39	3.34	1.04	.50	.20	.38	.03	.02	53.48	10.63	6.89
1981	49.19	2.42	.77	1.16	.83	.19	.04	-	.05	-	54.65	5.46	3.05
1982	60.74	2.85	2.28	.91	.39	.17	.07	-	.02	.01	67.45	6.71	3.86
1983	27.48	8.68	3.91	1.93	.38	.18	.07	.05	-	-	42.68	15.20	6.52
1984	22.23	4.79	2.29	.92	.24	.03	-	-	-	-	30.51	8.28	3.49
1985	89.94	16.30	3.53	3.13	.88	.07	.05	-	-	-	113.90	23.96	7.66
1986 ⁴	14.95	6.47	1.98	1.31	.29	.09	-	-	-	-	25.08	10.13	3.66

¹Adjusted from offshore #41 trawl catches to equivalent inshore-offshore #36 trawl catches using a .320:1 ratio.

²Adjusted from inshore-offshore #41 trawl catches to equivalent inshore-offshore #36 trawl catches using a .334:1 ratio.

³Adjusted from offshore #36 trawl catches to equivalent inshore-offshore #36 trawl catches using a .890:1 ratio.

⁴Preliminary estimates utilizing 1985 age data.